DOCUMENT RESUME

ED 208 247 CE 030 398

AUTHOR Seaman, George B., Sr.
TITLE Solar Energy Installers Curriculum Guide. Final Report, September 18, 1980-August 15, 1981.
INSTITUTION College of DuPage, Glen Ellyn, Ill.
SPONS AGENCY Illinois State Board of Education, Springfield. Dept. of Adult, Vocational and Technical Education.
PUB DATE Aug 81
NOTE 188p.; For related documents see ED 189 389-391.

EDRS PRICE MF01/PC08 Plus Postage.
DESCRIPTORS Air Conditioning; Competence; *Competency Based Education; Course Content; *Curriculum Development; Curriculum Guides; Curriculum Research; Heating; Learning Activities; *Learning Modules; Plumbing; Postsecondary Education; *Solar Radiation; Teaching Guides; Teaching Methods; *Technical Education; *Technical Occupations; Ventilation; Vocational Education

ABSTRACT

This publication is a curriculum guide for the installation of solar equipment. It is divided into the three major areas of general knowledge, technical design, and installation/maintenance. Associated is a list of relevant and prerequisite competencies identified as appropriate toward student interest groups of technician, installer, avocationist, and consumer. The step-by-step guide is designed to provide the teacher and/or curriculum developer with a comprehensive program in the technology of solar energy that can be used to train persons who wish to be service persons in the comfort industry. The guide was developed from analysis of job tasks required of heating, ventilating, air conditioning, and solar service workers. The guide consists of 11 units covering the following: introduction and theory (solar history, introduction to active solar, and the sun); engineering (the solar system); design (the collector, storage, and the electrical system); and installation and maintenance (whole house, solar application, and servicing solar installations). Unit guides for each unit contain instructional objectives, reference materials, visual aids, method performance conditions required of instructors, an outline showing a step-by-step breakdown of all subject matter to be covered, student evaluation criteria to meet competencies, and a sequence of instruction. Unit tests are provided. (The final project report describing the activities conducted to develop the curriculum guide is included in this package.) (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED208247

FINAL REPORT

SOLAR ENERGY INSTALLERS CURRICULUM GUIDE

REP NO. 80-133-4.4.2-A

George B. Seaman Sr. - Project Director
Technology Division
College of DuPage
Glen Ellyn, Illinois

Sponsored by:

ILLINOIS STATE BOARD OF EDUCATION
Donald F. Muirheid, Chairman

Donald G. Gill, State Superintendent of Education

DEPARTMENT OF ADULT, VOCATIONAL, AND TECHNICAL EDUCATION

August 1981

CE 030 398

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUC. TION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

C. Reisinger

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

FINAL REPORT

DEPARTMENT OF ADULT, VOCATIONAL AND TECHNICAL EDUCATION

FUNDING AGREEMENT NUMPER: R-33-21-D-0542-316

OFFICIAL PROJECT TITLE: SOLAR ENERGY INSTALLER

CURRICULUM GUIDES REP NO. 80-133-4.4.2-A

PROJECT DIRECTOR: George B. Seaman Sr.

FUNDED AGENCY: College of DuPage

LOCATION OF FUNDED AGENCY: 22nd Street and Lambert Road
Glen Ellyn, Illinois 60137

TIME PERIOD COVERED: September 18, 1980 - August 15, 1981

FINAL REPORT ABSTRACT: See appendix I

EXPENDITURE OF FUNDS: See appendix II

PAID PARTICIPANTS IN ACTIVITY

George B. Seaman Sr.
Project Director (Field Testing)
College of DuPage
Instructor/Coordinator in Department of Technology
Former High School Industrial Arts Teacher, Training Specialist United States Navy

Harion Enervold
Building Trades Instructor
Grundy Area Vocational Center
Area Vocational High School Instructor for the Building Trades

Zollie Hall
Director of Occupational Education
Spoon River College
Director of Occupational and Vocational Programs at the Community College Level

Ron Happach
Associate Professor
Sauk Valley College
Instructor of Heating, Air Conditioning, Engineering
Consultant, Registered Engineer

Ray Merry
Instructor Solar Energy
Lincoln College Program at Logen Correctional Center
Instructor in Solar Energy and running own firm specializing in Solar Energy

Harry E. Wallace
Assistant Professor
Black Hawk College
Instructor of Mechanical Power Technology, Heating and Air Conditioning

PRODUCT ABSTRACT: See appendix III

CONFERENCE/WORKSHOP SUMMARY: No conferences or workshops were conducted in relation to this project.

RESOURCE LISTING: No resources or instructional materials were purchased under this funding agreement.

ACCOMPLISHMENTS, INCLUDING SIGNIFICANT FINDINGS:

The first phase of the guide development made the assumption that the primary trainee would be the practicing heating and air conditioning tradesworker faced with a new technology appearing on the market. Additionally, the skills objectives at the job entry level assumed that competencies of conventional heating and air conditioning systems would be prerequisite to developing knowledges in the solar field. While this concept is valid in itself, it was found by the field testing activities that the guides have a positive application to additional student groups. With more and more commercial equipment appearing on the market and representing a considerable investment, it is extremely difficult for the consumer to make an intelligent buying decision. Secondly, the solar energy field has long been an area in which the do-it-your-selfer or avocationist has been active in solar energy utilization.

For these reasons, the units related to the Phase I Curriculum Guides was modified to be utilized for the three basic student groups. Units of study were clearly identified into the principal areas of introductory and theory; engineering; installation and maintenance. It is obvious that the level of skills achievement would vary between each student group. For this reason, a clear definition of trainee needs was developed and a competency level identified toward each group.

Technician - Competent to trouble-shoot equipment and make repairs. Must have a complete understanding of theory of operation and fault correction. Able to size equipment to meet requirements.

Installer - A complete competency in manual skills necessary to install new equipment. Some understanding of theory of operation necessary.

Avocationist - Most of the skills required of the installer and some of those of the technician, but on a more fundamental level - Project oriented.

Consumer - A thorough understanding of theory of operation but on a non-technical basis. An ability to perform basic maintenance tasks. Awareness of commercial equipments and their performance characteristics.

As a final task, it was felt that sufficient material was already available in the area of heating and air conditioning and that including those units in the solar guide would be redundant and serve only to produce a excessively bulky document. This is not to say that those units are not without value and through informal agreement with the Illinois State Board of Education will be made available as a separate publication.

MAJOR ACTIVITIES AND EVENTS

September/October - Materials made available - project started - internal review of Phase I - Guides and Validation - Budget reduced 10%

November - Attempts made to locate additional field test sites in southern region of the state - First contact with field testing sites which had indicated an interest in participation during Phase I of the project. - Final selection of field testing sites.

December/January - Coordination meetings with field testing sites.

January/June - Field testing of guides

April - Realization that insufficient time existed to properly evaluate field testing and produce an effective working product.

May - No cost extension to the contract.

June - Coordination meetings to develop the final concept and format of the solar guide.

July - Final collection of field testing comments and consolidation.

July/August - Re-writing of guides.

August - Publication approval by the state, publication, final report - preparation and delivery, product delivery.

PROBLEMS: See conclusions and recommendations.

PUBLICITY: No publicity was undertaken in connection with this project.

RESOURCE PERSONS: Resources were primarily those of the field testing sites and are listed under the section of "paid participants." In addition, Larry G. Munton, Director of Industrial and Technical Programs, Blackhawk College, contributed willingly of his time in developing format and organizational concepts for the final product.

SUMMATIONS OF EVALUATION DATA COLLECTED:

Evaluation data collected is significant in two principle areas. The first was the concept for the re-design of format and content of the final product. The details of this task are described in the section "Accomplishments, Including Significant Findings" of this report. The second area of evaluation data collected was related to the identification of competencies toward the requirements of the identified student group. Each of the field testing sites functioned independently on this phase, but it is interesting to note that with but just a few exceptions, contributors were in complete agreement.

STATEMENT OF IMPACT:

This publication consists of a curriculum guide for the installation of solar equipment which is divided into the three major areas of general knowledge, technical design and installation/maintenance. Associated is a list of relevant and pre-requisite competencies identified as appropriate toward student interest groups of technician, installer, avocationist, and consumer.

CONCLUSIONS AND RECOMMENDATIONS:

As evidenced by the secion "Major Activities and Events" the project required a six week time lag in its start up. The primary reason for this situation developing was that the Project Director for field testing was different than the Project Director for development. Out of necessity, a time lag was built in order to familiarize the new director with content and general approach to the first draft. This, of course, was further complicated by the fact that the former director was not available and no longer employed by the college, to assist in the transition. It is also significant to note that at start up time, the field testing sites had not been firmed up. As an end result, actual field testing was not started until January. Considering that an entire semester would be required to evaluate the guides, it therefore became necessary to extend revision times into the summer months. The following recommendations are therefore submitted for consideration.

1. Require that firm commitments be established for field testing sites in Phase I of the development.

2. Make provision that contracts start in June to preclude a down time in the summer months, and to insure a continuity of operation.

3. Lacking implementation of recommendation number two, make provision for the delivery of material in August.

STAFF DEVELOPMENT: NONE

OTHER ACTIVITIES: NONE

MATERIALS DEVELOPED: See Appendix Number III.

APPENDIX I

FINAL REPORT ABSTRACT

TITLE OF PROJECT: Solar Energy Installer

CURRICULUM GUIDES

FUNDING AGREEMENT NUMBER R-33-21-D-0542-316

PRINCIPAL INVESTIGATOR: George B. Seaman Sr.

INSTITUTION: College of DuPage
LOCATION: 22nd Street and Lambert Road, Glen Ellyn, Il 60137

TIME PERIOD COVERED: September 18, 1980 to August 15, 1981

OBJECTIVE OF THE PROJECT: To field test and revise a Solar Energy Installers Curriculum Guide.

PROCEDURES: Field Testing

EXPECTED CONTRIBUTION OR POTENTIAL ON VOCATIONAL EDUCATION:

This report covers the details of a project to field test and revise a Solar Energy Installer Curriculum Guide. The guide covers the three major areas of general knowledge, technical design and installation/maintenance. Associated with the guide is a list of relevant and pre-requisite competencies identified to student interest groups of technician, installer, avocationist and consumer.

PRODUCTS DELIVERED:

Solar Energy Installers Curriculum Guide - 500 copies delivered to the Illinois State Board of Education, Department of Adult, Vocational, and Technical Education. 200 copies on August 17th. 300 copies by freight the week of August 17th.

Final Report Solar Energy Installers Curriculum Guide - 20 copies delivered to The Illinois State Board of Education, Department of Adult, Vocational and Technical Education, 12 copies on August 17th, 8 copies by U. S. Mail the week of August 17th.

APPENDIX II.

EXPENDITURE OF FUNDS

THE EXPENDITURE OF FUNDS SUMMARY WILL BE FORWARDED FOR INCLUSION IN THIS REPORT AT A LATER DATE.

Solar Energy Installers Curriculum Guide

Gene C. Walker
George B. Seaman Sr.
Project Directors

Department of
Technology
College of DuPage
Glen Ellyn, Illinois

Illinois State Board of Education

Donald F. Muirheid
Chairman

Donald G. Gill
State Superintendent
of Education

Adult,
Vocaticnai and
Technical Education

Research and
Development Section

June, 1981

FOREWORD

The Illinois State Board of Education is committed to assisting local communities in the development of quality instructional programs to prepare for the rapidly emerging technology of Solar Energy. The Solar Energy Installers Curriculum Guide is designed to provide the teacher and/or curriculum developer with a comprehensive program in the technology of Solar Energy. The guide provides flexibility in that competencies have been identified for technicians, installers, avocationals and consumers. Teachers and curriculum writers, therefore, have a great deal of latitude in design to fit individual student groups, learning styles and training methods.

Sincere appreciation is extended to all those in the Heating and Air-conditioning Industry who contributed so much in developing this curriculum guide. Recognition is given to the following individuals for their outstanding contribution: Gene C. Walker, Project Director (Authorship); Richard R. Miller, Director of Development; Patricia Polonus, Typist; Lucille Edwards, Researcher; all of the College of DuPage. Also many thanks to the Advisory Board consisting of Shirle Vaughn, Solar Ray System Inc.; T. L. Bremer, Bremer Sheet Metal; Harold S. Gray, Control'd Engineering Supply; Harold M. Levy, Kennedy-King College; Lawrence Felker; Robert Barclay Company; George Ruble, Central Furnace Supply; Robert Forty, Energy Service Company; David J. Mincheski, Decar Heating and Cooling; Lou Kohley, College of DuPage; Gene May, Youngrens, Inc.; Michael Kirkpatrick, K & M Heating and Air Conditioning; Farell W. Pelfrly, Environmental Energy Systems Inc.; James Fitzgerald, Michael Hudspeath, Solar Energy Products; Jack Zaruba, JZ Alternate Energy Products Corporation; James McGowan, Solar Products Inc.; James A. Hartley, NISEA. For their efforts in field testing of this document; George B. Seaman Sr., Project Director (Field Testing); Harry E. Wallace and Larry G. Munton, Black Hawk College; Harion Enervold, Grundy Area Vocational Center; Ronald H. Happach, Sauk Valley College; Zollie W. Hall, Spoon River College; Ray Merry, Logan Correctional Center.

Donald G. Gill
State Superintendent of Education

Contents

Forward I

Product Abstract II

Contents

Introduction 1

Instructional Resources 12

Unit Guides 20

Competencies 70

Unit Quiz and Exams 119

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material: Solar Energy Installers Curriculum Guides

2. Date material was completed: 15 August 1981

3. Please check one: New material [X] Revised material [ ]

4. Originating agency: College of DuPage
   Address: 22nd & Lambert Rds., Glen Ellyn, IL Zip Code: 60137

5. Name(s) of developer(s): Gene Walker & George Seaman, Sr.
   Address: College of DuPage, 22nd & Lambert Rds., Glen Ellyn Zip Code: 60137

6. Developed pursuant to Contract Number: R-33-10-X0442-316
   R-33-21-X-0542-316

7. Subject Matter (Check only one according to USOE Code)

   USOE Code

   - [ ] 01 Agricultural Education
   - [ ] 03 Business and Office Education
   - [ ] 04 Distributive Education
   - [ ] 07 Health Occupations Education
   - [ ] 09 Home Economics Education
   - [ ] 10 Industrial Art Education
   - [ ] 16 Technical Education
   - [X] 17 Trade and Industrial Education
   - [ ] 22 Cooperative Education
   - [ ] Career Education
   - [ ] Other (Specify)

8. Education Level

   - [ ] Pre-K Thru 6
   - [ ] 7-8
   - [ ] 9-10
   - [ ] 11-12
   - [X] Post-Secondary
   - [X] Adult
   - [ ] Teacher (Pre-service)
   - [ ] Administrator (Pre-Service)
   - [ ] Other (Specify)

9. Intended for Use By

   - [ ] Student
   - [X] Classroom Teacher
   - [ ] Local Administrator
   - [X] Teacher Educator
   - [ ] Guidance Staff
   - [ ] State Personnel
   - [ ] Other (Specify)

10. Student Type

    - [X] Regular
    - [ ] Disadvantaged
    - [ ] Handicapped
    - [ ] Limited English Proficiency
    - [ ] Other (Specify)

11. Medium and Format of Materials

[X] HARDCOPY	[ ] VIDEOTAPE	[ ] FILM	[ ] MICROFICHE
No. of pages 175	[ ] Minutes	[ ] Minutes	[ ] B & W
[ ] Paper bound	[ ] B & W	[ ] B & W	[ ] Color
[ ] Hard bond	[ ] Color	[ ] Color	
[X] Loose-leaf	[ ] inches	[ ] mm	
Photos: Yes [ ]	No [ ]		
Diagrams: Yes [X]	No [ ]		

___ SLIDES	___ FILM STRIPS	___ AUDIO	___ OTHER
No. of frames _____	No. of frames _____	___ Automatic synch	Specify
___ B & W	___ B & W	___ _____ Hz	_____
___ Color	___ Color	___ Manual cue	_____
___ Audio	___ Audio	___ Reel	_____
___ Carousel provided		___ Cassette	
___ Other packaging used (Specify) _____		___ Cartridge	

12. Availability

_____ One copy free For sale @ $ _____ per copy _____ Not available
_____ In ERIC system (No. _____) _____ Loan copy available

Contact: Name _____ Phone ( ) _____
Address _____ Zip Code _____

13. Copyright Restrictions:

Contact: Name _____ Phone ( ) _____
Address _____ Zip Code _____

14. Is Training Required for Optimum Use of These Materials? Yes_____ No_X_

15. Are Consultive/Training Services Available? Yes_____ No_X_

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
100 North First Street
Springfield, IL 62777
(217) 782-4620

16. General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Continue on back of this sheet or on another sheet, if necessary.). This publication consists of a curriculum guide for the Installation of Solar Equipment which is divided into the three major areas of General Knowledge, Technical Design and Installation/Maintenance. Assoicated is a list of relevant and prerequisite competencies identified as appropriate toward student interest groups of Technician, Installer, Avocationist, and Consumer.

17. Person Completing this Abstract: George B. Seaman, Sr.

Full Address:
College of DuPage
22nd & Lambert Rds.
Glen Ellyn, IL Zip 60137

I. INTRODUCTION

A. Solar Energy

Solar energy technology has existed for hundreds of years but development has not been eagerly pursued due to the expense.

In our present situation the increasing cost of energy and the growing problem with obtaining fossil fuels makes another look at solar energy development imperative.

Cost is becoming less and less a basis for making the decision to go to an alternative energy source, as the availability of cheap energy sources decreases.

Those who use their foresight to develop alternate energy systems will be in a more secure position in the future.

B. Solar Energy Technician and Installer

The need for trained installers and service persons is a never-ending requirement for any mode of the Comfort Conditioning Industry.

Employment needs for Solar Energy Technicians (SET's) were derived from (1) U.S. Department of Energy estimates of the current and projected number of solar homes in the United States; (2) the number of year-round housing units in Illinois; and (3) the average amount of time required to design, install and maintain solar space and water heating systems. The U.S. Department of Energy estimates that there are 40,000 solar homes in the United States at the present time and that there will be 2.5 million solar homes by 1985.[1] This represents an 80 per cent annual increase

1 Research Institute Recommendations, Vol. 29, No. 33. New York: The Research Institute of America. August 18, 1978.

in the number of solar homes; by 1983 there will be approximately 750,000 solar homes in the country.

Illinois accounts for 5.5 percent of the year-round housing units in the United States.[2] Assuming it is representative of the rest of the United States in its current and projected use of solar energy for home heating purposes, it was estimated that within Illinois there are currently 2,183 solar homes and by 1983 there will be 41,250 solar homes in the State. During 1983, 18,333 solar heating systems will be installed in homes in Illinois.

To estimate the employment impact of this increase in the use of solar energy for home heating, figures from a Navarro College study of solar energy technology were used[3]. That study determined that the expected time required to design, install and maintain solar home heating systems was 10, 40, and 2 hours, respectively. The total design and installation time of 50 hours was divided into the number of work hours in a person-year (2080) in order to determine the number of solar heating systems that one SET could handle in a year (41.6). By dividing the number of systems that would be installed during the year 1983 (18,333) by the number of systems which one SET could design and install (41.6) an estimated 441 full-time SET's will be needed in 1983.

The number of SET positions which will be needed in 1983 in order to maintain the 41,250 solar heating systems was derived by multiplying the number of systems which will be in operation (41,250) by the number of hours per year required to maintain each system (2).

---

2 Census of Housing, Vol, I. U.S. Bureau of the Census, 1970.

3 Navarro College, Assessment of Need for Developing and Implementing Technical and Skilled Worker Training For the Solar Energy Industry, Navarro College, Corsicana, Texas, January 1978.

This resulted in 82,000 SET hours needed for maintenance of systems in 1983. By dividing the number of hours required for maintenance (82,500) by the number of work hours in a person-year (2,080), it was estimated that an additional 40 full-time SET's will be needed to maintain solar heating systems. When added to the number of SET's required to design and install systems (441), a total of 481 SET's will be needed by 1983.

To estimate the growth from present SET employment, it was assumed that all of the 2,183 existing solar homes were built in 1978. The number of SET's required to design, install, and maintain the systems this year will be 55. Thus, the growth in SET employment from 1978 to 1983 is estimated to be 426.

The replacement rate for SET's was obtained by using the rate for plumbers and pipefitters, which is estimated to be 10 per cent over for the next five years[4]. This figure was applied to the 1978 SET employment of 55 to yield five additional positions needed due to replacements. Thus, the total growth and replacement needs for SET's between 1978-1983 is estimated to be 431.

The regional distribution of solar energy technicians in Illinois was assumed to follow that of plumbers and pipefitters. The figures used to estimate regional distribution of SET's is presented in Table 9.

C. Solar Energy Systems Education for the Avocationist and Consumer

The avocationist or do-it-yourself home builder needs an understanding of the basics of comfort conditioning systems including heating, cooling & ventilation as a foundation for learning how to choose the most efficient solar energy system for his home and to properly install it.

---

4 Illinois Manpower Projections, op. cit.

Table 9

Derivation of Projected Five-Year Employment Requirements for Solar Energy Technician

Region	Plumbers/ Pipefitters	Percent of Total Employment	Total Demand (1978-1983)
1	1064	4.19	18
2	16305	64.14	276
3	401	1.58	7
4	655	2.58	11
5	316	1.24	5
6	1047	4.12	18
7	292	1.15	5
8	1069	4.21	18
9	260	1.02	4
10	527	2.07	9
11	811	3.19	14
12	184	0.72	3
13	1188	4.67	20
14	213	0.84	4
15	169	0.66	3
16	85	0.33	1
17	411	1.62	7
18	94	0.37	2
19	131	0.52	2
20	197	0.77	3
Total	25,419	100.00	431

Note: Rounding may cause discrepancies in totals.

D. The Solar Energy Consumer

The consumer, whether constructing a new building using solar energy or converting an existing structure to solar energy, needs to know some of the basics of heating, cooling and ventilating as well as the basics of solar energy systems. This knowledge will serve him well in choosing the type of system best suited to his facility or home and assuring himself of proper procedures used in its installation.

E. Need for Guides

The need for curriculum guides for training for solar energy installers, technicians, avocationists, and consumers, was made apparent when College of DuPage's HVAC Program Coordinator started to research the availability of existing course guides.

Since the time that a need was determined, June 1978, several manufacturers of solar products have come out with their own guides and many schools have developed programs-- as indicated in Illinois Solar Energy Directory, page 83: Solar Energy Education Programs in Illinois. However, on page 92, Energy Education Materials, under Curriculum Aids, there is no listing of a guide for solar installers.

The manufacturers' manuals are slanted toward their own product--deservedly so-- and the other institutional programs are mostly oriented toward consumers and design engineers.

These findings made it apparent that a Solar Installer's Guide which consolidated all installation procedures in a step-by-step manual was needed.

The curriculum guides that follow were developed to be used in training persons who have a desire to be servicepersons in the comfort industry. The title may be of a misleading nature, if it

is assumed that all that will be taught through these guides is solar. Due to the sunbelt that Illinois falls into, it is necessary for us to use backup systems along with solar. At this point in time most solar design applications are at 60% solar and 40% backup heat. For this reason having knowledge about the back-up systems is a necessity. Also to make one's self employable and a viable serviceperson, it is necessary to have a good foundation in all realms of the heating, cooling, refrigeration, ventilating and solar industry.

For people such as carpenters, plumbers, salespersons, and technicians it may be very beneficial to combine use of Solar Energy Installers Curriculum Guides with Illinois Solar Energy Systems Installation Training Program. These two curriculum guides used in conjunction with each other will cover all areas of the solar industry.

The Solar Energy Installers Curriculum Guides were developed from careful analysis of job tasks required of the Heating, Ventilating, Air Conditioning, Solar-Serviceworkers. Competencies were developed and approved through an advisory board made up of individuals from industry.

II. USING THE SOLAR ENERGY INSTALLERS CURRICULUM GUIDES

A. Determine Student Needs

The curriculum guides have been laid out according to areas which have been subtitled under unit numbers.

First determine the area of study desired. Next determine the competencies already possessed by the student in order to write a program which will meet his needs.

If reading unit titles is not sufficient to write a program of instruction, look for the instructional objectives and outlines

of materials to be covered. The instructor should then be able to develop a program of units which the student must take to become proficient at the job task level and extent desired by the student. Student evaluation parameters listed under each unit should match the competencies desired.

B. Teaching of the different units can progress by use of the unit's guidelines.

1. Instructional objectives are laid out.
2. Reference materials are listed for each unit and chapters, sections, pages, etc., are noted.
3. Visual aids are indicated along with any materials available to instructors.
4. Method performance conditions required of the instructors are listed.
5. An outline showing a step-by-step breakdown of all subject matter to be covered is listed.
6. Student evaluation parameters to meet competencies are listed.
7. Sequence of instruction is listed for all units.

   NOTE: This sequence may be varied in its order, but all steps should be covered.

   Unit tests are provided with all units where necessary-further testing may be desired.

C. It should be noted that the curriculum provided is to be used as a guide to develop the specific training requirements of the student in question. The never ending advances in the comfort industry may make it necessary to update or modify units within this guide.

III. CAREER LADDERS

A. Job Entry Level - beginning student, job entry apprentice, helper, stockperson, laborer

B. Learning Level - second-year student, second-year apprentice, counter sales, component person (one who deals with specific products only) Expect high school diploma or GED.

C. Semi-Skilled Level - certification/degree-bearing student (AA-Community College), third-year apprentice, in-house sales

D. Skilled Level - certificate or degree-bearing student with two years of field experience (total 4 years), journey person, outside sales, technician

E. Specialist Level - on-site sales, on-site sizing, equipment and system design person, technical service, trouble-shooting person

F. Supervisory Level - foreperson/lead person, customer service and sales representative (in-house level), inventory control person (computer), assistant manager

G. Management Level - owner of HVACS shop, contractor or subcontractor, business manager, sales manager, territorial manager or service manager, parent company, main management, board member

SOLAR INSTALLER CAREER LEVELS

7 OWNER, CONTRACTOR, MANAGEMENT

6 FOREPERSON, LEAD PERSON, SUPERVISOR, ASSISTANT MANAGER

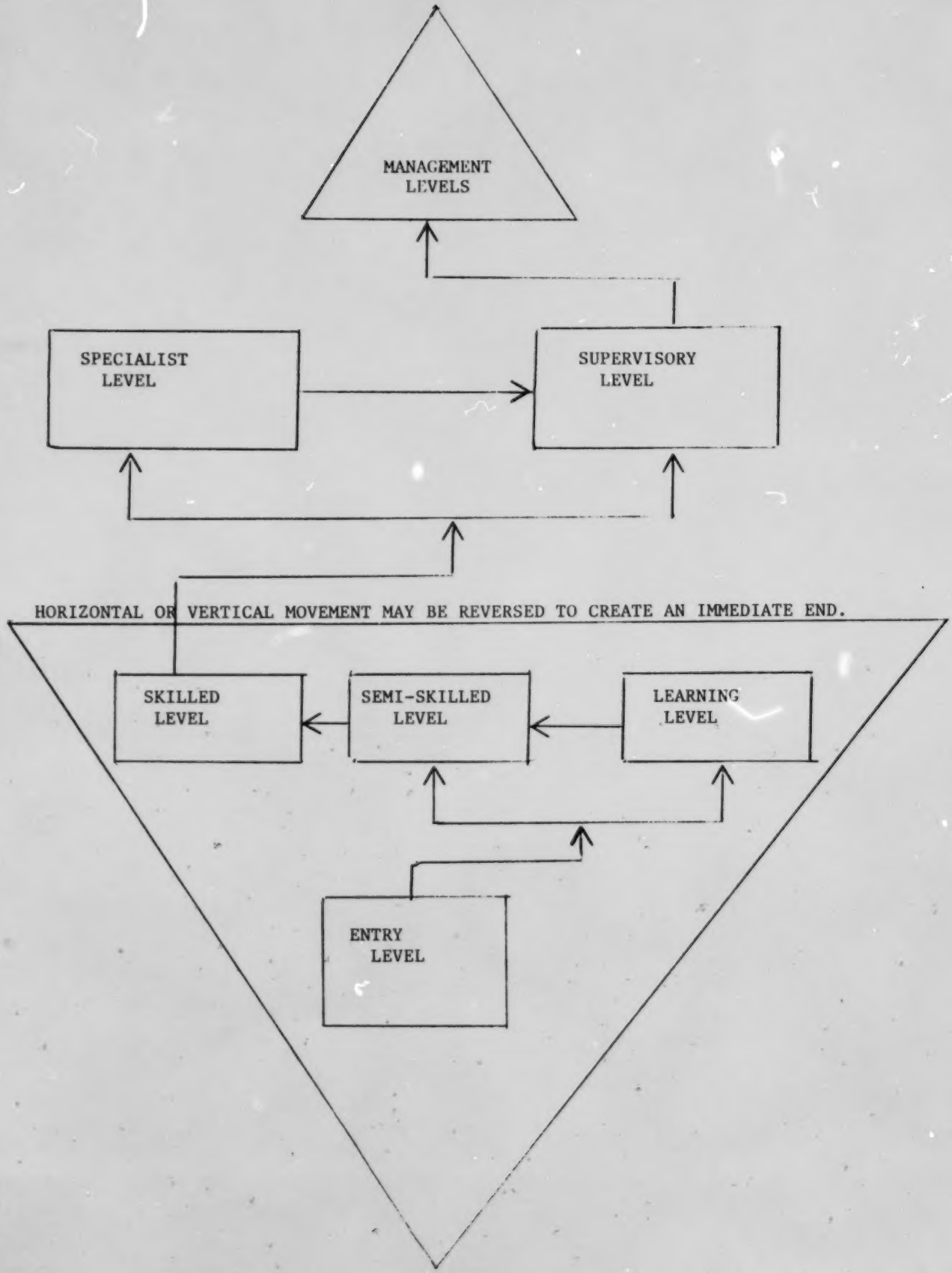
5 TECHNICAL SERVICE PERSON, ON SITE SALES, SPECIALIST, TROUBLE SHOOTER

4 JOURNEY PERSON, GRADUATE STUDENT (SKILLED AND EXPERIENCED

3 ADVANCED APPRENTICE, 2 YEAR DEGREE, SEMI-SKILLED

2 LEARNING LEVEL
COMPONENT PERSON, DEGREE SEEKING STUDENT, APPRENTICE

1 JOB ENTRY
HELPER, LABORER, STOCK PERSON, BEGINNING STUDENT, APPRENTICE


MANAGEMENT
LEVELS
SPECIALIST
LEVEL
SUPERVISORY
LEVEL
HORIZONTAL OR VERTICAL MOVEMENT MAY BE REVERSED TO CREATE AN IMMEDIATE END.
SKILLED
LEVEL
SEMI-SKILLED
LEVEL
LEARNING
LEVEL
ENTRY
LEVEL

INSTRUCTIONAL RESOURCES

Slide Set	Kai Dib Films International Richard L. Crowther, AIA, Solar Group Architects Sun Earth: Solar Architecture
Text & Slides (also available)	Solar Energy and Heating Systems P.O. Box 261 Glendale, California (1977)
Slide Set and Trainers	Lennox Industrial Inc. - Lennox Phase I (SA) Solar Application Lennox Educational Products (Iowa-Texas) 1600 E. Linn Marshalltown, Iowa 50158 (1978)
(Other educational trainers)	RT-5, EB-5, ST-17, AP-3
Trainer System (total)	Suncell Solar Heating System Research Products Corporation Madison, Wisconsin 53701 (1977)
Texts	Sun Earth: How to Apply Free Energy Sources to Our Homes and Buildings Crowther/Solar Group 310 Steele Street Denver, Colorado 80206 (1977)
	Student Guide Sheet Metal Shop Practice American Technical Society (1976) Chicago, Illinois 60637
	Sheet Metal Technology Richard S. Budzik The Bobbs Merrill Company, Inc. (1979) Indianapolis, Indiana 46268
	Sheet Metal Shop Practice Leo A. Meyer American Technical Society (1975) Chicago, Illinois 60637
	Air Conditioning Metal Layout Joseph J. Kaberlein Benziger Bruce & Glencoe, Inc. (1973) Beverly Hills, California 90211
	Practical Layout for the Sheet Metal Shop Zinngrabe and Schumacher Delmar Publishers (1975) Albany, New York 12205

Texts (con't)

The Solar Decision Book: A Guide for Heating Your Home with Solar Energy, by Richard H. Montgomery (John Wiley & Sons, New York. 1978)

Fundamentals of Solar Heating (Correspondence Course)
U. S. Department of Energy
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161 (1978)

Heating and Air Conditioning Systems Installation Standards for One and Two-Family Dwellings and Multi-Family Housing, Including Solar, by Better Heating and Cooling Bureau (1977) SMACNA

Illinois Solar Energy Directory- Illinois' Alternative Energy Program.
Green and Pogany
325 West Adams Street, Room 300
Springfield, Illinois 62706 (1978)

National Solar Energy Education Directory
Solar Energy Research Institute
1536 Cole Blvd.
Golden, Colorado 80401 (1979)

Solar Energy Systems - Liquid, Air, Storage Systems
Solaron Corporation
440 Gallerig Tower (Application Engineering Manuals,
720 S. Colorado Blvd. Installation Manuals, Owners Manuals,
Denver Colorado 80222 and Design Manuals.)

Job-Related Training - Solar
Lennox Air Conditioning and Heating Inc.
Lennox Education Products
1600 E. Linn,
Marshalltown, Iowa 50158 (1978)

Model Document for Code Officials on Solar Heating and Cooling of Buildings (1979)
U. S. Depart of Energy
Cont. #EM-78-C-01-4281

Solar Energy - Progress and Promises
Council on Environmental Quality (1978)
Superintendent of Documents
Washington D. C. 20402
Stock #041-011-0036-0

Solar Energy in America's Future
Division of Solar Energy
Energy Research and Development Administration
Washington, D. C. (1977)
Stock #060-000-00078-6

Texts (con't)

Solar Energy Information and Data for Illinois, by Changnohs
Illinois State Water Survey (1978)
Cir. No.133 - (12-78-1500)

Solar Energy Handbook - Theory and Application
Power Systems Group AMETEK Inc.
Chilton Book Company/Radnor, Pennsylvania (1979)
Library of Congress Card No. 78-14646

Proceedings of Solar Energy Storage Options, Vols 1 & 2
March, 1979, San Antonia, Texas
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22161
Cont. 790328-P1
Final Report H-C0199-79-753F (1979)

Suncell Solar Heating Systems
Research Products Corporation (Solar Division)
Madison, Wisconsin
and
Solar Energy in Industrial Process Heating
Installation Manuals, DHW & Total House

Installation Guidelines for Solar DHW Systems in One and Two-Family Dwellings, by Franklin Research Center
Philadelphia, Pennsylvania
Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402
Contract #H-2377

Revere Sun-Pride System
Revere Solar and Architectural Products, Inc.
Rome New York 13440
Installation Manual - DHW & Total House

Design Manual for Solar Heating of Buildings and Domestic Hot Water, by Field.
Sol Pub Co.
P. O. Box 9209
College Station, Texas 77840 (1977)
Publication 501

Design Criteria for Solar Heated Buildings
Sunworks Technical Publication (1975)
Sunworks, Inc., Guilford, CT 06437

Energy and Solar Heating, by Bason
An Issue-Oriented Module Coordinated by AA of PT (1977)
Michigan State University

Texts (con't)

DOE Facilities Solar Design Handbook (1978)
U.S. Dept. of Energy DOE/AD-006/1
National Technical Information Service
U.S. Dept. of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Stock #061-000-00097-6

Solar Energy in Buildings - For Engineering, Architecture and Construction
John Wiley & Sons, New York (1979)

Here Comes the Sun - A Manual Explaining Practical Solar Heat Applications with Blueprints for Solar Systems Using Air and Water, by Xoxon
Jordan College, Michigan (1977)

Energy Saving Conservationist Solar Systems
A. O. Smith Corp.
Consumer Products Division - Solar Catalog (1978)
Kankakee, IL
7250 S. Cicero Avenue
Chicago, IL 60629

Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings (1976)
Energy Reseafch and Development Administration
Division of Solar Energy
Washington, D. C. 20543
NBSIR 76-1187

SEM - 79
Solar Engineering Master Catalog - Solar Industry Index
Solar Energy Industries Association
Solar Engineering Publishers Inc.
8435 N. Stemmons Freeway
Dallas, Texas 75247

Basic Sheet Metal Skills
Philip M. Johnston and Murray Liebowitz
Delmar Publishers (1977)
Albany, New York 12205

Sheet Metal Layout
Leo A. Meyer
Gregg Division/McGraw Hill Book Company (1979)
New York, New York

Precision Sheet Metal Shop Theory
Richard S. Budzik
Howard W. Sams & Company, Inc. (1969)
Indianapolis, Kansas City, New York

Texts (con't)

Duct Design for Residential Winter & Summer Air Conditioning & Equipment Selection
Air Conditioning Contractors of America
Air Conditioning Contractors of America (1979)
Washington, D.C. 20036

Load Calculation for Residential Winter & Summer Air Conditioning
Air Conditioning Contractors of America
Air Conditioning Contractors of America (1975)
Washington, D.C. 20036

Equipment Selection & System Design Procedures
National Environmental Systems Contractors Association
National Environmental Systems Contractors Association (1973)
Arlington, Virginia 22209

Comfort Heating
Billy C. Langley
Reston Publishing Company, Inc.(1978)
Reston, Virginia 22090

Domestic & Commercial Oil Burners
Charles H. Burkhardt
McGraw Hill Book Company (1969)
New York, New York

Fundamentals of Gas Combustion
American Gas Association Laboratories
American Gas Association (1973)
Arlington, Virginia 22209

Trane Reciprocating Refrigeration
The Trane Company
The Trane Company (1977)
LaCrosse, Wisconsin

Industrial Refrigeration Course I
Elliott R. Hallowell, Guy R. King, & Ivan C. Stepnich
Refrigerating Engineer & Technicians Association & National Association of Refrigerated Warehouses (1972)
Chicago, Illinois 60611
Washington, D.C. 20014

Industrial Refrigeration Course II - Systems
Refrigerating Engineers & Technicians Association
Refrigerating Engineers & Technicians Association (1975)
Chicago, Illinois 60611

Texts (con't)

Refrigeration and Air Conditioning
Billy C. Langley
Reston Publishing Company, Inc. (1978)
Reston, Virginia

Environment Control Air Conditioning and Refrigeration Theory and Application
Michael K. Weaver, James M. Kirkpatrick
Harper & Row Publishers (1974)
New York, San Francisco, London

Modern Refrigeration and Air Conditioning
Andrew A. Althouse, Carl H. Turnquist, Alfred F. Bracciano
The Goodheart-Willcox Company, Inc. (1975)
South Holland, Illinois

Refrigerants and Service Pointers Manual
E. I. DuPont DeNemours & Company
E. I. DuPont DeNemours & Company (1970)
Wilmington, Deleware 19898

Refrigeration and Air Conditioning
Air Conditioning and Refrigeration Institute
Prentice Hall, Inc. (1979)
Englewood Cliffs, New Jersey 07632

Basic Air Conditioning
Guy R. King
Nickerson & Collins Company (1965)
Chicago, Illinois 60644

Principles of Refrigeration
Roy J. Dossat
John Wiley and Sons (1978)
New York, Santa Barbara

Trane Air Conditioning Manual
The Trane Company
The Trane Company (1977)
LaCrosse, Wisconsin

Control Systems for Heating, Ventilating & Air Conditioning
Roger W. Haines
Delmar Publishers (1978)
Albany, New York 12205

Understanding Solid-State Electronics
Texas Instruments Learning Center
Texas Instruments Learning Center (1977)
Fort Worth, Texas 76107

Texts (con't)

Job Related Training-Lennox Air Conditioning & Heating
Lennox Industries (1977)
1600 E. Linn
Marshalltown, Iowa 50158
Phase 1(S), 11(S), 111(S)

Honeywell Residential Controls Training
Honeywell (1971)
2701 4th Avenue S.
Minneapolis, Minnesota 55408
Gas Controls, Oil Controls, Air Conditioning Controls, Cooling Controls, Controllers

Electric Circuit Fundamentals
Prentice Hall, Inc. (1979)
Englewood Cliffs, New Jersey 07632

Handbook of Simplified Electrical Wiring-Lenk
Prentice Hall, Inc. (1975)
Englewood Cliffs, New Jersey 07632

Basic Electricity-Honeywell Residential Training Manual
Minneapolis-Honeywell Regulator Company (1958)
Minneapolis, Minnesota

Electric Modulating Controls Service Handbook
RA 890 Service Handbook
Honeywell Tradeline Controls

Fundamentals of Pneumatic Controls
Robert Shaw Uni-Line Division (1976)
P.O. Box 2000
4190 Temescal Street
Corona, California 91720

Workbench Guide to Electronic Troubleshooting-Genn
Parker Publishing Company, Inc.(1977)
West Nyack, New York

Control Theory and Fundamentsl Study Course 1 & 2
RETA
435 North Michigan Avenue
Chicago, Illinois 60611

Electric Controls for Refrigeration and Air Conditioning
Langley
Prentice Hall, Inc. (1974)
Englewood Cliffs, New Jersey 07632

Texts (con't)

Copper Brass Bronze Product Handbook
Copper Tube
Copper Development Association, Inc.
405 Lexington Avenue
New York, New York 10017

Carrier GTR & GTE Service Training Aids
Carrier Air Conditioning Company
Syracuse, New York

Magazines and Newspapers

Solar Products Specifications Guide
Solar Age Magazine
P. O. Box 4934
Manchester, New Hampshire 03108

Solar Age
P. O. Box 4934
Manchester, New Hampshire 03108

SERI - Solar Energy Research Institute
1617 Cole Blvd.
Golden, Colorado 80401

UNIT GUIDES

SOLAR APPLICATION INSTALLATION

INTRODUCTORY & THEORY

Unit 1 SOLAR HISTORY
Unit 2 INTRODUCTION TO ACTIVE SOLAR
Unit 3 THE SUN

ENGINEERING

Unit 4 THE SOLAR SYSTEM

DESIGN

Unit 6 THE COLLECTOR
Unit 7 STORAGE
Unit 8 ELECTRICAL SYSTEM

INSTALLATION & MAINTENANCE

Unit 9 WHOLE HOUSE
Unit 10 SOLAR APPLICATION
Unit 11 SERVICING SOLAR INSTALLATIONS

AREA - SOLAR APPLICATION INSTALLATION

Unit 1 - Solar System History

I. Instructional Objective

The student will realize that people have been trying to harness the sun's energy and put that energy to work for many centuries. It is this scientific approach in the past that in part, at least, accounts for our present solar systems that have been operational for several decades. It is important for the student to understand the purpose of these sytems and the fact that present energy situations have brought solar systems to the attention of all. It is project ingenuity like this that provides the scope of future achievements in solar development.

II. Reference Material

Lennox Solar (Volume I) Solar Systems Past and Present 1-57
Solaron - Solar Energy Systems Section 100
Sun Earth Chapter 7
Solar Decision Book Section 5 and 6
Solar Energy Progress and Promise pages 1-43
Solar Energy in America's Future pages 15-43

III. Visual Aids

Lennox Slide Presentation 1 (SA) ISASS-781-L5 - Slide 1-9
Kaibib Film, International Sun Earth (H35-H46)

IV. Method - Performance Conditions

The slides authentically illustrate past experiments for utilizing solar energy. They are to be used to explain the idea and operation of these early devices. The project information (see reference materials) and slides provide references to establish the concepts of residential solar space heating and domestic hot water systems. The students are encouraged to discuss these systems as time allows. Sun Earth slides will give a total overview of historic use of natural energies.

V. Outline

1. Purpose
   A. Energy Conservation

2. Early Solar Technology
   A. Solar stove
   B. Printing Press
   C. Water purification

3. Demonstration projects
   A. Discussion

4. Solar past and present
   A. Past
      (1) Babylon 2100 B.C.
      (2) Hopi Indians
      (3) Archimedes 212 B.C.
          a. solar reflectors
      (4) France 1600 A.D.
          a. solar engine
      (5) France 18th century
          a. solar furnace
      (6) United States 1800's
          a. solar hot air engines
      (7) Pifre's solar press
      (8) Tellier flat plate collector - 1885
      (9) Solar food preparation - 1916
   B. Present - early 1970's
      (1) 1930-1970 - 50 solar homes total
      (2) September 1975 HVD
          a. go over 55 different HUD demonstrations

VI. Student Evaluation Parameters

Student will identify the four main solar alternate energies - passive and active solar systems - wind - wave - biomass. Application of any one of these systems in past or present day situation mock ups will be demonstrated on paper.

VII. Sequence of Instruction

1. Read assigned reference materials.
2. View assigned slide presentations.
3. Discuss in class the effects of alternate energies through history that have advanced up to today's technology.
4. Take unit test (paper written on mock up use of one of any four of our solar energies).

AREA - SOLAR APPLICATION INSTALLATION

Unit 2 - Introduction to Active Solar

I. Instructional Objective

Introduction to Solar Heating and Cooling explains the basic concepts, structure, and economic considerations involved with solar heating and cooling. The lesson is designed to be a comprehensive introduction which will permit an overall understanding, together with some insight, to the economic implications involved with these systems.

The student will be exposed to a portion of the private and governmental emphasis that is currently directed toward solar systems as a developing technology. Obviously, these solar projects provide a prime opportunity to become aware of the complexities encountered when attempting to collect and store the sun's energy. The student will understand the need for accountable solar standards and codes wherever solar applications are completed.

The legal responsibilities for those who design, engineer, install, and use solar assisted heating systems are two-fold. There is responsibility for (1) the heath and safety of people who may be in contact with the system, and (2) the protection of the property in order to construct and maintain an efficient and effective heating system.

People must be informed about possible toxic or allergic reactions that result from contact with materials used in the system. There is also the possibility of electrical shock or burns.

Property must be protected by enforcing building codes and licensing practices for installers and servicing personnel. There are also problems related to real estate that deal with appraisal practices, incentives to invest in solar heating, insurance, and warranties of components in the system.

II. Reference Material

Fundamentals of Solar Heating (Lesson I & II)
Solaron - Solar Energy Systems Section 300
Lennox Solar (Volume I) Solar Systems Present
Solar Decision Book Section 7
Model Documents for Code Officials on Solar Heating and Cooling of Buildings Section B
Solar Energy Handbook Chapter 1

III. Visual Aids

35 MM Slides Lennox

IV. Method - Performance Conditions

The 35 MM slides are used to generate a discussion concerning the purpose of solar systems and the approaches that have led to that goal. The general discussion will be guided to cover key points such as the state of the technology, architectural compatability, and the difficulties associated with working with a variable heat source. Each student will be given the opportunity to talk about his solar experiences.

V. Outline

1. State of the technology
   - A. Heating
     - (1) space
     - (2) hot water preheat
     - (3) swimming pools
   - B. Cooling
     - (1) absorption
     - (2) mobile solar system
   - C. Solar - heat pump

2. Role of ERDA, HUD and like agencies
   - A. Financial assistance

3. Collector installations
   - A. Methods
     - (1) roof
       - a. structural considerations
     - (2) ground level
   - B. Architecturally pleasing
   - C. Three dimensional zoning
   - D. Variable heating values

4. Storage
   - A. Methods
     - (1) water
     - (2) rock

5. Building codes
   - A. FHA guidelines

6. Systems
   - A. Marv Anderson
   - B. French solar system
   - C. Ocean system

7. Student participation
   - A. Seminar attendance
   - B. Local installations

8. Economic analysis/Life cycle costing
   - A. Factors affecting economics
   - B. Commerical/Industrial application
   - C. Life-cycle cost analysis - sample calculation
   - D. Computer life-cycle cost analysis worksheet

VI. Student Evaluation Parameters

1. The student will do sample life cycle costing analysis.
2. The student will discuss local and federal agencies involved with solar.
3. Name the major components of a solar heating and solar cooling system.
4. Distinguish the differences between air and liquid systems.
5. Identify the differences within the component groups.
6. Describe what types of systems have practical value as opposed to systems under development with possible future promise.
7. Explain the difference between active and passive solar heating.
8. Describe the basic expectations of performance of different types of systems.
9. Recognize the advantages and disadvantages of the various types of components within a system.
10. Identify and describe the economic implications of solar heating and solar cooling.
11. List all the items involved in costing a system.
12. Name the climatological characteristics which are involved in sizing a solar heating/solar cooling system.
13. Explain how the availability and cost of conventional fuels will impact on solar heating/solar cooling.
14. Describe the hazards of a solar heating system to people and property.
15. Identify and explain the problems relating to right to light and freedom from glare.
16. Discuss building codes and zoning requirements.
17. Identify minimum quality standards and installation requirements for solar systems.
18. Describe problems related to property appraisals.
19. Analyze problems related to incentives to invest in a solar system.
20. Identify problems relating to insurance and solar systems.
21. Describe problems relating to warranties and solar systems.

VII. Sequence of Instruction

1. Read assigned material.
2. Quiz on building codes.
3. View slides.
4. Take Unit 2 quiz.

AREA - SOLAR APPLICATION INSTALLATION

Unit 3 - The Sun

I. Instructional Objective

Solar Radiation explains what this course is all about - the use of the solar energy which reaches earth for heating and cooling. In this lesson, you will discover the way energy given off by the sun is altered before it reaches the earth, and how the energy that does reach the earth can best be utilized. Thus, your objective will be to recognize the factors which affect the availability of solar radiation at the earth's surface.

The student will become knowledgeable of the energy intensity ranges of light radiation. Variables, such as latitude, reflection, diffusion, altitude, climatic season, and air mass number will allow the student to account for energy losses and explain the heat energy available for collection at the earth's surface. This will provide an insight as to the best orientation possible for a collector type. Weather and radiation data tables are a convenient means to tabulate the effects of all variables. The student will be able to read and extract needed data from typical reporting stations. The student will be exposed to data gathering instrumentation and will be expanding his technical vocabulary to accommodate the mechanics of this variable heat source.

II. Reference Material

Lennox Solar (Vol. 1) Sun 1-13
Solar Energy Handbook (Chapter 2 & 3)
Solar Decision Book (Chapter 5)
Fundamentals of Solar Heating (Lesson 2)
Solaron Solar Energy Systems Section 400 (1-5)
Energy and Solar Heating (Solar Radiation 16-29)
Solar Energy in Formation and Data for Illinois
Suncell Installation Manual (Page 2)

III. Visual Aids

Lennox Slides (10-26)
Sun Earth Slides 69-123

IV. Method - Performance Conditions

The instructor should ask a series of probing questions concerning observed seasonal positions of the sun and atmospheric conditions that would affect collection of solar energy. During this class discussion the slides are used to reinforce, intensify and stimulate interest and information in the various subject areas. Students are called upon to interpret information in weather data tables and the radiations charts. This may be in front of the class so the student has the opportunity to control discussions. Test instruments are passed around the class and students are encouraged to keep their discussion in terms of the technology.

V. Outline

I. Solar mechanics

A. Earth - Sun plane
   (1) earth's axial tilt - 23-½°
   (2) sun tracting
      a. Tropic of Cancer
      b. Tropic of Capricorn

B. Seasonal changes
   (1) altitude of sun
      a. summer - winter solstice
      b. vernal - autumnal equinox
      c. BTU per area on horizontal differences
   (2) horizon
   (3) azimuth angle
   (4) zenith

2. Solar radiation

A. In space
   (1) beam radiation
      a. spectral analysis
   (2) solar constant (428 BTUH/FT^2) = S_c

B. At earth's surface
   (1) types
      a. beam
      b. diffused
      c. reflected
   (2) altitude above sea level
   (3) latitude
   (4) air mass number
   (5) radiation belts
   (6) radiation charts
      a. graph explanation
   (7) intercepting solar radiation
      a. solar noon
      b. tilt angle for collector
      c. azimuth angle
      d. altitude of sun angle
   (8) climatic conditions
      a. cloud cover

C. Solar weather and radiation data tables
   (1) reporting stations
      a. data taken between 11 A.M. and 1 P.M.
   (2) latitude
   (3) horizontal radiation
   (4) fraction of maximum
      a. cloud cover influences
      b. relate to S_c
   (5) degree days (D-D)
      a. definition - 65° base
      b. example
      c. heating requirement notation used by gas companies
   (6) tilted surface variations

D. Instrumentation
   (1) pyronometer
   (2) temperature

E. Vocabulary
   (1) degree day
   (2) azimuth
   (3) altitude
   (4) beam radiation
   (5) tilt angle (slope)
   (6) solar noon
   (7) air mass number
   (8) diffused
   (9) reflection
   (10) insulation
   (11) solar constant
   (13) zenith
   (14) shortwave radiation

3. Solar energy in space
   A. Radiation reaching outer atmosphere
      (1) types of radiation
      (2) altitude and its affect on radiation
      (3) average daily radiation
      (4) solar radiation belts
      (5) radiation charts
   B. Weather data instruments
      (1) pyronometer
      (2) wind speed and direction
      (3) temperatures ambient
   C. Intercepting solar radiation
      (1) collector tilt angle
      (2) azimuth angle

VI. Student Evaluation Parameters

1. Recognize those conditions - for example, clouds, dust and other atmospheric pollutants; shading from trees and buildings; and collector orientation and tilt - which affect solar energy reaching the collector.

2. Describe the difference between direct and diffuse radiation.

3. Recognize the various units of measure used to report solar radiation.

4. Convert solar radiation fron one unit of measure to another using standard coversion factors.

5. Determine the amount of solar radiation available for a given period of time.

6. Describe the effect of seasonal variations.

7. Recognize the importance of hourly variations.

8. Learn and locate sources of solar data.

9. Select the data needed for planning a solar system.

10. Blend the information learned in Unit 1, 2 and 3 into a singular unit of knowledge.

VII. Sequence of Instruction

1. Read assigned reference material.

2. View slides.

3. Work sample problems in Sun's Angle in Respect to Alignment of Panels.

4. Take Unit 3 Quiz.

5. Take Unit 1, 2 and 3 examination.

6. Energy and Solar Heating, do exercises 13-19, lab exercise, page 23.

AREA - SOLAR APPLICATION INSTALLATION

Unit 4 - Solar System Design Engineering

I. Instructional Objective

To present the basics of solar system operation. The relationships which must exist between the collector, storage unit, auxiliary furnace, pumps, fans, heat exchangers, and other vital parts of the total system are presented. Finally, the control system which regulates the flow of air and liquid through solar heating systems is discussed.

It is essential that the student develop the architectural perspective that allows a typical three dimensional solar space heating system to be visualized in a pictorial piping arrangement or in a single line mechanical layout. Both design formats are encountered industry-wide and the student will be well versed to intelligently describe each. The student will be able to construct these design graphics to scale to help assure a complete solar system at the time of installation. The student will also be able to recognize and implement the correct graphic symbol to represent system components in all diagrams.

Solar heating of domestic hot water (DHW) is growing rapidly in the United States. Many solar domestic hot water heating systems are available for new installations as well as retrofitting into existing homes. This lesson introduces the basic types of systems available, considers each of the principal components of the system individually, discusses the operation of these systems, presents information about sizing the components, and deals with the principal economic question which must be answered before deciding to purchase a solar domestic water heating system.

II. Reference Material

Lennox Solar (Vol. 1) Equipment Selection
Solaron Solar Energy Systems - Section 400 and 500
Solar Design Handbook
Design Criteria for Solar Heated Buildings - Chapter 5
Fundamentals of Solar Heating Lesson 7 and 8

III. Visual Aids

Lennox Slides (27-41), (97-118)
Lennox Worksheet Example
Sun Earth Slides 62-68

IV. Method - Performance Conditions

The slides are used to convey the basic design principles. They provide a working model which illustrates three important areas. The students, via discussion, should attempt to establish these: (1) spacial relationships must be duplicated in the design, (2) general knowledge of installation and component function is desirable and (3) drawings that are complete and to scale are the basis of the valuable bill of

materials list for each job. The students will be required to respond to symbols on the slides for a detailed description.

V. Outline

1. Engineering drawings
   - A. Pictorials
     - (1) description
   - B. Mechanical layout
     - (2) description

2. Symbols
   - A. Components
     - (1) check valve
     - (2) circuit setter
     - (3) gate valve
     - (4) relief valve
     - (5) filter
     - (6) three-way valve
     - (7) pump

3. Installation hints
   - A. Filter in horizontal pipe
     - (1) sedimentation bowl
   - B. Gate valves
     - (1) isolation of major components
       - a. globe
         - 1. equivalent length
       - b. consider circuit setter
   - C. Circuit setter
     - (1) establish flow rate prior to collector entry
   - D. Pump
     - (1) secure
     - (2) eliminate vibrations
   - E. Check valves
     - (1) location

4. Bill of materials list
   - A. Itemizing procedure
     - (1) example

5. Design (systems engineering)
   - A. Preliminary estimating techniques
   - B. Criteria for sizing
   - C. Heat loss
   - D. Collector orientation
   - E. Collector tilt
   - F. Calculation procedure
   - G. Water
     - (1) flow direction
     - (2) flow rate
     - (3) pressure drop
     - (4) piping and manifolding
     - (5) slope of headers
     - (6) pressure relief

(7) expansion contraction
(8) freeze protection
(9) overheating protection
(10) corrosion protection

6. Solar and standby system control interlock
   A. Collection sub-system
   B. Water drainback system (siphon or open drop)
   C. Glycol collector
   D. Heat exchanger design

7. Pump design
   A. Determine pumping head
   B. Glycol effect on flow rates
   C. Glycol effect on pumping head
   D. Glycol effect on pump curve
   E. Compression tank
   F. System leak and sludge protection and prevention

8. Design
   A. Air-air handling unit
   B. System description
   C. Motorized dampers
   D. Backdraft damper

9. Solar system vs. building heating requirements
   A. Collector orientation south
   B. Tilt
   C. Shading/solar window
   D. Flashing and mounting
   E. Structural considerations

10. Solar energy collection - water
   A. Types of solar heating - systems collector tech. data sheets
      (1) description
      (2) panel details
      (3) mounting details
      (4) dimension and performance
      (5) warranty
   B. Collector spacing
   C. Guide specifications

11. Collection tech. data - air
   A. Specification and performance data
   B. Air manifolding
   C. Dimensions of collector and perimeter flashing
   D. Typical collector arrays
   E. Spacing for flat roof/free standing

12. Sizing
   A. Sample calculations
   B. Conversion factors
   C. Sizing work sheet
   D. Auxiliary heating system and duct work
   E. Outside air - calculation procedure

13. F Chart calculations
    A. Space heating and domestic hot water sample calculation
    B. Worksheet
    C. Domestic hot water only, F Chart
    D. Sample calculations
    E. Worksheet
    F. Heating degree days
    G. Weather data
        (1) solar radiation
        (2) average daily temperature
        (3) each month

VI. Student Evaluation Parameters

1. Describe the five basic operating modes for air solar heating systems.

2. Determine which components of the systems should be operating and which valves or dampers should be open during each operating mode.

3. Describe the importance of eliminating air leaks in all air solar heating system.

4. Identify the safety devices required on the domestic hot water subsystem.

5. Identify the basic differences between air and hydronic solar heating systems.

6. Describe three different ways heat pumps can be coupled to solar heating systems.

7. Describe the three basic types of solar domestic water heating systems and identify the basic components of each.

8. Understand and be able to discuss the advantages and disadvantages of air versus liquid systems.

9. Describe the operating cycles of the three basic systems for heating domestic water.

10. Analyze the economic considerations which are important to the decision to purchase a solar domestic water heating system.

11. Student will be capable of working through sample load sizing problems such as introduced through Lennox slides.

VII. Sequence of Instruction

1. Read assigned reference material.

2. View slides

3. Discuss slides and work sample problems.

4. Take Unit 4 quiz.

AREA - SOLAR APPLICATION INSTALLATION

Unit 5 - The Solar System

I. Instructional Objective

Introduction to several methods of selecting the size of the key components of a typical solar heating system. The techniques presented are based upon research data and provide varying degrees of precision, depending upon their levels of sophistication. Students will have the opportunity to consider several important economic factors and learn how they can affect the size of the most economical solar heating system. Also, in this lesson, information will be provided to help the student use a computerized system which is available to compute the size of the components required for a solar heating system.

The student will begin to think of the base line system, that is, solar space heating and hot water, in terms of functional subsystems. The subsystems will include the collector loop with purge capabilities, the storage loop, pre-heat for domestic hot water, an auxiliary heat source, and the electrical logic system. The student will be able to itemize all mechanical components in each subsystem and explain the purpose and operation of each device. In this manner, a general understanding of the interrelationship of subsystems to the overall solar system performance will result. It will be necessary for the student to recognize and associate graphic symbols to the exact system component as might be viewed on a mechanical layout of a base line system. In addition, the student will be required to adopt and utilize a new solar vocabulary when discussing system composition. Proper terminology is of paramount importance to help eliminate possible confusion in this new technology.

The student will learn about sizing the collector. Once the size of the collector is known, it is possible to compute the size of each of the remaining solar system components. Your previous experiences with forced air and hydronic heating systems will aid your study.

II. Reference Material

Lennox Solar (Volume 1) (Components and Operating Modes)
Solaron Solar Energy Systems, Section 600 Systems
Fundamentals of Solar Heating, Lesson 6
Installation Guidelines for Solar BHW Systems, Page 1-58
Solar Energy Handbook, Chapter 6
Sun Earth, Chapter 3

III. Visual Aids

Lennox Slide Presentation (42-73)

Component parts
A. Hand valve
B. Check valve
C. Circulation pump
D. Strainer
E. Circuit setter - balancing valve

F. Aquastat controller
G. Pressure relief valve
H. Differential controller and sensor
I. Return air limit
J. Air separators
K. Compression tank with airtrol
L. Collector
M. Heat exchanger
N. Three-way valve
O. Space heating coil
P. Purge coil
Q. Storage tank
R. Hot water coil

AP-3 Solar System Trainer - Lennox, or equivalent

AP-4 Solar System Trainer Kit - Lennox, or equivalent

RT-5 Solar Cycle Trainer - Lennox, or equivalent

IV. Method - Performance Conditions

The slides are used to introduce the integral components of each of the subsystems. The operation of the components is determined, both by slides and live component parts. Following questions and discussion over each subsystem, they are integrated into a complete, functional solar system. This information can be transferred to a mechanical layout of the solar hydronics using all appropriate symbols. Either the Lennox AP-3 or AP-4 or equivalent are convenient vehicles to show a compact system in terms of a mechanical orientation. The trainers also allow for descriptively illustrating fluid flow during operation. After completing this exercise the student should draw an understandable mechanical layout of the system. Throughout this presentation typical hydronic terminology is employed. NOTE: all of the aforementioned demonstrations can be built as a class project, dependent on funding available for course offerings.

V. Outline

I. The Solar System
  A. Collector loop
    (1) collectors
      a. types
      b. methods for removing heat
    (2) air separator
      a. purpose
      b. baffles - velocity effect
    (3) compression tank
      a. expansion of fluid
        1. pressure effect
        2. relief valve
      b. airtrol device
        1. operation
      c. necessity for closed system

(4) centrifugal pump
  a. purpose
  b. design
  c. couplers
  d. lubrication
  e. motor sizes
  f. impellers
  g. cavitation
  h. air bound problems
(5) purge coil
  a. purpose
  b. forced convective
  c. convective
(6) circuit setter
  a. purpose
  b. indication settings
  c. test parts
(7) three-way valve
  a. operation
(8) strainer
(9) check valve
(10) piping
  a. type - reverse return
  b. connections
(11) fluid
  a. 50% Glycol
    1. properties
      aa. density
      bb. specific heat
      cc. specific gravity
      dd. pressure drops
      ee. laminar flow
      ff. turbulent flow
(12) heat exchanger
  a. single pass
  b. multi-pass
  c. reverse flow
  d. shell
  e. tube bundle
  f. temperature crossover
(13) Pete's plug

B. Storage loop - water or rock
(1) storage tank
  a. capacity
(2) space heating coil
  a. limit
  b. location
(3) heat exchanger
(4) centrifugal pumps
(5) check valve
(6) compression tank

C. Hot water preheat
(1) preheat coil
(2) water tempering valve

51

D. auxiliary heat
   (1) gas
   (2) oil
   (3) electric
   (4) heat pump
E. Electrical logic system
   (1) differential controller (3K)
      a. sensors
   (2) aquastats
      a. purge (5K)
      b. storage (4K)
   (3) relays
   (4) limit
   (5) valve
   (6) pump

2. Electric Logic System
   A. Differential controller (3K)
      (1) temperature sensors
         a. collectors
         b. storage
      (2) directs heat flow in system
         a. to storage
         b. to space heating coil
         c. to purge
   B. Aquastats
      (1) storage (4K)
      (2) purge (5K0
   C. Return Air Limit
      (1) safety
   D. Control center
      (1) relays
   E. Thermostat
   F. Three way valves
      (1) energized position

3. System Operation
   A. Heat Collection
      (1) overview of heat distribution
         a. storage
         b. space heating
         c. purge

4. Mechanical Layout
   A. Illustration
      (1) symbols
         a. hydronic components

5. Terminology
   A. Heat transfer
   B. GPM
   C. CFM
   D. BTU
   E. Insulation
   F. Fluid

Additional Components to Discuss

I. Liquid system
   A. Antifreeze solution
   B. Heat exchanger
   C. Purge coil
   D. Filters and strainers
   E. Air separator
   F. Compression tank fittings
   G. Compression tank
   H. Centrifugal pump
      (1) pump sizing
   I. Storage tank
      (1) tank sizing
   J. Immersion well
   K. Solar heat coil
   L. Tempering valve
   M. Pressure relief valve
   N. Balancing valve
   O. Check valve
   P. Gate valve
   Q. Three way valve
   R. Air vent
   S. Test plug and gauge adapter
   T. Copper tubing
      (1) sizing
   U. Insulation

II. Air
   A. Collectors
   B. Internal manifold
   C. Air handling equipment
   D. Motorized dampers
   E. Back draft dampers
   F. Duct work
      (1) sizing
      (2) sealing air tight
   G. Insulation

III. Modes of Operation
   A. Heat from collector to heated space
   B. Heat from collector to storage
   C. Heat from storage to heated space
   D. Summer water heating
   E. Second stage heat back-up: solar and heat pump
   F. Second stage heat pump, no collector or stage heat (back up elect. resistance may be 3rd stage if needed)

IV. Systems
   A. Space Heating
      (1) one zone
      (2) with air conditioning/or continuous air circulation
      (3) swimming pool water
      (4) heat pumps
      (5) two zones

(6) two or more zones
(7) without storage
(8) process fluids
(9) outside air
(10) water
(11) off peak storage

VI. Student Evaluation Parameters

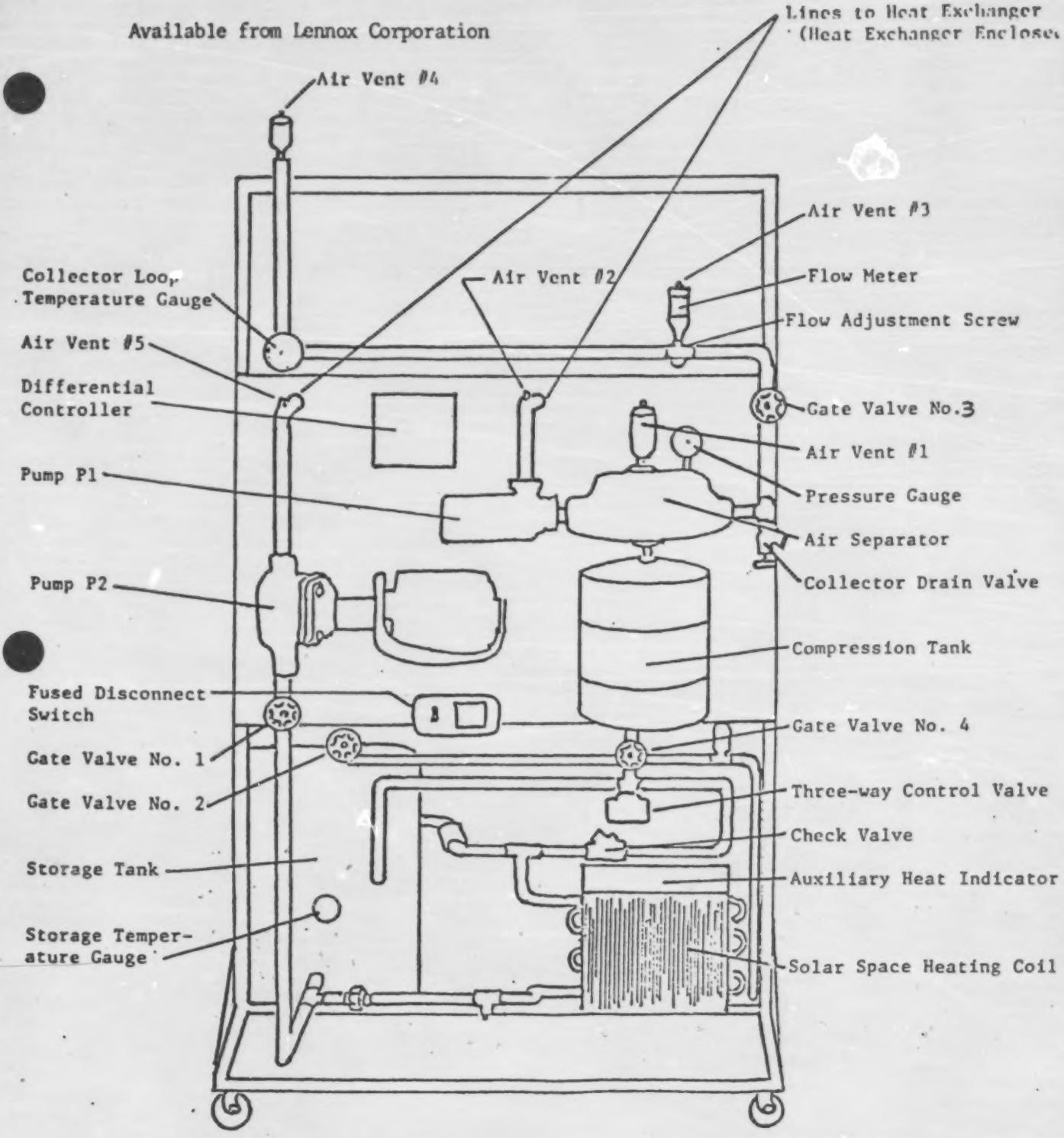
1. Identify ten components of a typical solar heating system
2. Define the term "life-cycle-cost."
3. Use tables to determine the collector size for typical homes.
4. Identify the more important economic factors in sizing solar heating systems.
5. Calculate the size of the heat storage unit required for a typical collector.
6. Calculate the size of the pumps or fans which circulate water and air through the collector.
7. Prepare the input for a computer program which will compute the size of solar system components.

VII. Sequence of Instruction

1. Read assigned reference materials.
2. View slide presentation.
3. Discuss all components in class.
4. Demonstrate and show all components in class.
5. Take Unit 5 Quiz.
6. Take Unit 4 and 5 Exam.

TRAINER PARTS DIAGRAM

Available from Lennox Corporation



RT-5 SOLAR CYCLE TRAINER - Available from Lennox Corporation

Introduction

There are many mechanical and electrical variations that can occur in a solar space heat/domestic hot water system. Fluid flow can be routed in numerous ways to:

a. use the sun's energy directly for heating;

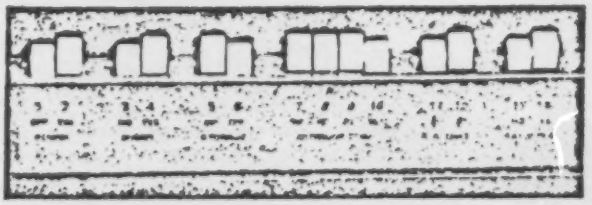
b. store the sun's energy to be used at a later date;

c. use hot water from storage for space heating;

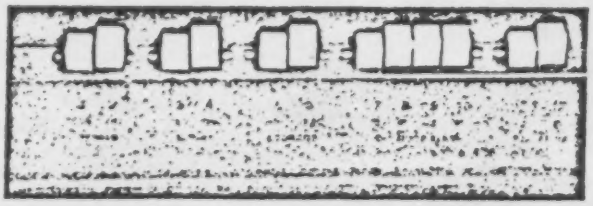
d. use hot water from storage for domestic water heating;

e. rid the system of excess heat.

The RT-5 Solar Cycle Trainer permits the instructor to isolate the flow patterns and discuss what is happening. The EB-5 Schematic Trainer is designed so electrical control sequences can be programmed to match these patterns shown on the RT-5.



Switch Panel On The RT-5



Switch Panel On The EB-5

Switch Identification for RT-5 and EB-5

Switch 1	Power Off
Switch 2	Power On
Switch 3	No Sun
Switch 4	Sun
Switch 5	Storage, 80°F or Below
Switch 6	Storage, 170°F
Switch 7	Outdoor Temperature 70°F
Switch 8	Outdoor Temperature 45°F
Switch 9	Outdoor Temperature 20°F
Switch 10	Outdoor Temperature 95°F
Switch 11	Open Solar Coil Limit (R.A. Limit)
Switch 12	Closed Solar Coil Limit (R.A. Limit)
Switch 13	No Water Use
Switch 14	Water Use

(Switches 13 and 14 are on the RT-5 only).

AP-3 SOLAR SYSTEM TRAINER - Available from Lennox Corporation

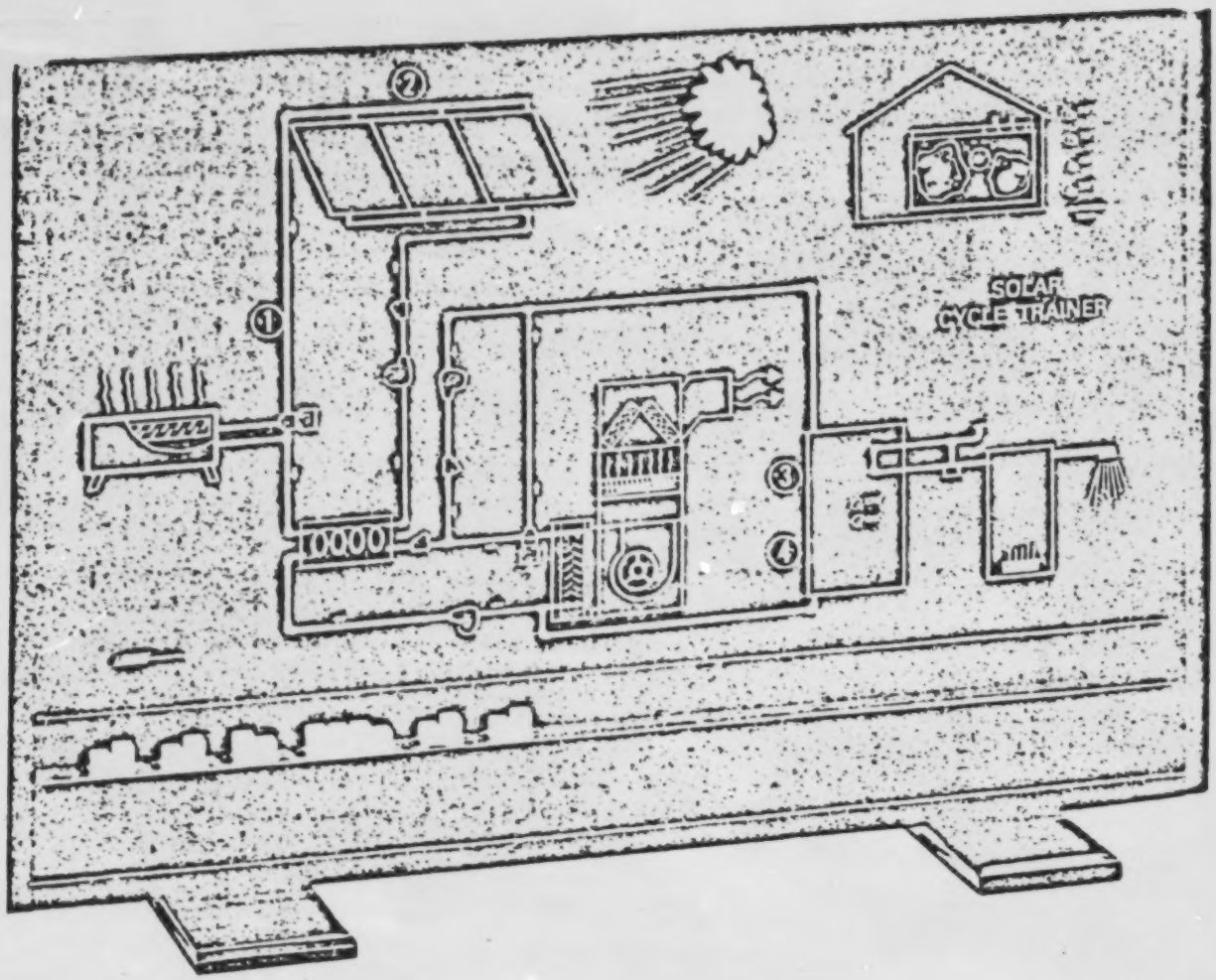
Introduction

The AP-3 Solar System trainer is designed to acquaint the student with fundamentals of solar hydronic heating systems. The trainer aids the student in acquiring an understanding of individual components and the interrelation of these components when applied to solar heating. The trainer shows the student how pressure and temperature affect system operation. The student also learns charging procedure and system startup.

Trainer Design

The AP-3 is a portable, self-contained unit shipped completely assembled. The collector is secured to the trainer frame at a tilt angle of 52^{o}. The trainer may be moved to any convenient location where solar radiation is available. The trainer will also function under artificial light, such as heat lamps. See "Components", "Operating Modes" and "Control" sections of Lennox Solar Manual for further explanation. Refer to Trainer Parts Diagram and Flow Loop Diagram for location of components and flow loop identification.

Available from Lennox Corporation



RT-5 SOLAR CYCLE TRAINER

(Locations of Sensors)

1. **Purge Aquastat Sensor**
2. **Collector Sensor (3K)**
3. **Storage Aquastat Sensor (4K)**
4. **Storage Sensor (3K)**

AREA - SOLAR APPLICATION INSTALLATION

Unit 6 - The Collector

I. Instructional Objective

The collector, which comes in contact with solar radiation, is the topic for Unit 6. Explanations are given of (1) various types of collectors, (2) how collectors are designed and manufactured, and (3) how collectors transfer the solar radiation into hot air or liquid.

A study of the solar collector, commonly referred to as the "heart" of the solar assisted heating system. Regardless of the fluid (air or liquid) which will be moved through the collector, the functions are the same; namely to collect solar radiation and convert it to heat energy. This unit deals with the concepts of the function and design.

In this unit the student will be introduced to various types of collectors, such as air collectors, fluid collectors, and focusing collectors. The advantages and disadvantages of each will be pointed out and the student will be required to itemize these. Attention will be given to flat plate collector construction, the various ways collector losses occur and the methods implemented to minimize those losses, and the variables affecting overall collector efficiency. It is important for the student to be able to read collector performance curves and use this information as a base for comparing collectors. The student will calculate collector efficiencies utilizing both performance curves and collector heat removal data. The student will calculate the number of collectors necessary for space heating and domestic hot water requirements for typical residential dwellings. The monthly percentage of load f-chart method will be employed. Other methods of determining collector area will be illustrated. The student will focus on payback aspects of solar heating systems and the criteria that influence solar heating decisions. There is additional terminology that is assimilated into the student's solar vocabulary.

II. Reference Material

Lennox Solar (Vol. I) Solar Energy Collector
Solaron Solar Energy Systems - Section 200 and 500
Fundamentals of Solar Energy - Lesson 3
Installation Standards (4-1)
Solar Decision Book, Chapter 9 and 10
Solar Energy Handbook - Chapter 5

III. Visual Aids

RP Products Collector (Suncell)
Lennox LSC18-1S collector
Slides Lennox (27-41)
Collector calculation forms
Sun Earth Slides 27-32

IV. Method Performance Conditions

The slides are used to stimulate class discussion concerning various types of collectors. The students then can formulate a comparison chart listing the features of each type. The slides depict engineering advances that result in increased efficiency of the collector. A collector is disassembled to illustrate the construction of the collector. Sample problems, completed as a group activity, can be used to demonstrate collector efficiency. The problems can be compared to the performance curves in towns of heat removal. The worksheets allow everyone in the group to tabulate the information necessary to calculate the collector surface area and annual load capability. Adequate sample problems should be completed so everyone is confident using the material. A brief explanation covering the sizing method is given. A group discussion of payback periods, cost versus performance, and procedures for estimating these variables should conclude this segment using any available worksheets or methods. Proper terminology is continuously stressed.

V. Outline

I. Collectors
- A. Air
  - (1) vacuum tube
  - (2) flat plate
    - a. solaron
  - (3) window slabs
- B. Fluid
  - (1) glycol-water mix
- C. Focusing
  - (1) concave concentrator
    - a. absorber
  - (2) lens
  - (3) beam radiation
- D. Criteria
  - (1) cost
  - (2) weight
    - a. wind load
  - (3) roof
    - a. area
    - b. strength
  - (4) future uses
    - a. absorption cooling
- E. Construction
  - (1) insulation
  - (2) transparent covers - low iron (Fe)
    - a. etching
  - (3) substrate - absorber plate
    - a. absorptance
  - (4) selective coatings
    - a. reradiation characteristics
    - b. colors
  - (5) manifolding ports
  - (6) weather resistance

F. Methods of heat loss
   (1) reflectance losses
   (2) transmission losses
   (3) convection losses within the collector
   (4) reradiation losses
   (5) ambient losses
G. Performance curves and efficiencies
   (1) inlet fluid temperature
   (2) ambient temperature
   (3) solar radiation (Q inc)
   (4) intercept (FR) T
   (5) slope (FR) UL
      a. comparing collector efficiencies
   (6) heat removal rate
H. Specifications
   (1) flow rate
      a. SR-1 Dowtherm
         1. -34°F F.P
         2. 0.25 Centripoise @ 160°F
         3. 232°F B.P.
         4. thermal conductivity 0.23 BTU/16°F
   (2) stable 850°F
   (3) areas
   (4) weight
   (5) emessivity -0.10
   (6) transmittance -0.96
   (7) absorptivity -0.94
I. Collector sizing
   (1) short form method
      a. LC factor
      b. SA/L
      c. degree-day (U_A)
   (2) worksheets I, II, IIa fraction of annual load-monthly base
J. Payback
   (1) escalating fuel prices
   (2) interest rates
   (3) operating cost
   (4) installation cost
   (5) maintenance
   (6) taxes
K. Terminology
   (1) slope
   (2) intercept
   (3) thermal conductivity
   (4) degree day
   (5) selective coating
   (6) shortwave radiation
   (7) longwave radiation
   (8) reflectance loss
   (9) incident flux (Qinc)
   (10) f-chart
   (11) density
   (12) specific heat
   (13) specific gravity
   (14) centipoise
   (15) emessivity

2. Focusing collectors
   A. Concentrator
   B. Absorber

3. Flat Plate Collector
   A. Construction
   B. Transparent covers
   C. Absorber plate
   D. Liquid Collector
      (1) fluids
   E. Air collector
   F. Insulated box and frame
   G. Collector performance
      (1) intercept
      (2) slope
      (3) curves
   H. BTU capacity of collector
   I. Comparison between liquid and air
      (1) advantage liquid
      (2) disadvantage liquid
      (3) advantage air
      (4) disadvantage air
   J. Summarize

VI. Student Evaluation Parameters

1. Explain the differences between flat plate and concentrating collectors.
2. Identify the differences in how air and liquid collectors are designed.
3. Describe the operating principles of various components in the collector.
4. Recognize different absorber plate designs and method of manufacture.
5. Describe total mechanics in construction of collectors.

VII. Sequence of Instruction

1. Read all reference material.
2. View all slides.
3. Work with demonstrator collectors
4. Discuss panel design and construction
5. Take Unit 6 quiz.

AREA - SOLAR APPLICATION INSTALLATION

Unit 7 - Storage

I. Instructional Objective - Comparison of Storage Materials
Unit 7 is a study of the heat storage unit of a solar assisted heating system. Regardless of the fluid (air or liquid) which will be used as the heat transfer medium, the functions are the same; to store heat for circulation at night or during times of low solar insolation. This unit deals with the concepts of the function and design but not specifications that a manufacturer or contractor would use for a given heat storage unit.

II. Reference Materials
Proceedings of Solar Energy Storage Options, Vol. #1 & 2
Installation Standards, Solar 10-1
Fundamentals of Solar Heating, Lesson 4
Solaron Installation Manual, Heat Storage Residential and Commercial

III. Visual Aids
Tours of Existing Storage
Lennox Slides 67 and 75
Overheads of Suncell Storage Systems

IV. Method Performance Conditions
The students, by means of review, are called upon to draw the different types of storage systems for water and air type collectors. All components should be labelled. The necessity for insulating and tight sealing of all components should be discussed and stressed. A small mockup of storage system should be designed using proper materials and fabricating procedures.

V. Outline
I. Air
A. Residential
(1) heat storage unit, principles of
a. concrete construction
b. wood construction
(2) sizing
(3) rock sizing
(4) attachment to system
(5) metal lath
(6) bond beam block
(7) transite or spiral duct details

(8) construction
- a. calculate size
- b. determine location
- c. excavate if necessary
- d. footings
- e. construct walls
- f. install tie rod
- g. seal interim air tight
- h. install insulation
- i. install floor air system
- j. install diamond mesh
- k. obtain right size rock
- l. clean rock
- m. install rock (carefully)
- n. caulk and install lid

2. Commercial
   A. Same as above except sizing methods differ

3. Water
   A. Sizing the tank
   B. Placement of tank
   C. Insulation of reservoir

VI. Student Evaluation Parameters

1. Identify what material is used for heat transfer mediums.
2. Explain the concepts of sizing a heat storage unit.
3. Solve problems of storage unit sizing.
4. Discuss where storage units can be placed.
5. List factors that affect the advantages and disadvantages of different kinds of heat storage units.
6. Identify advantages and disadvantages of various heat storage practices.
7. Describe the materials used in manufacture and in installation practices for heat storage units.

VII. Sequence of Instruction

1. Read all reference materials.
2. View all overheads and slides
3. Discuss different solar storage options and designs.
4. Fabricate a storage system.
5. Take Unit 7 quiz.

AREA - SOLAR APPLICATION INSTALLATION

Unit 8 - Electrical System

I. Instructional Objective

Unit 8 is a study of the various controls and specialty items of a solar assisted heating system. Blowers and dampers move and divert air in an air system. Centrifugal pumps and valves move and divert liquids in a liquid system. Many of these controls are electrically operated and, for the most part, are made-up of components commonly used by electricians, plumbers, and/or sheet metal workers in the heating-cooling industry.

The student will become accustomed to the mechanical modes of operation and the electrical devices that result in these varying flow patterns. It is a necessity to know the exact flow path of fluid through all subsystems in each mode of operation. The student will be able to trade fluid or air flow through the solar piping or duct arrangements. In addition, the student will follow through electrical schematic wiring diagrams to gain an understanding of the electrical logic systems. Wiring diagrams will correspond to each mode of operation.

II. Reference Materials

Lennox Solar (Vol. I) Control
Fundamentals of Solar Heating - Lesson 5
Installation Standards Solar - Section 6-1
Solar Decision Book - 17
Installation Guidelines for Solar DHW Systems - page 65
Solaron Solar Energy Systems - Air-Section 500 and 600
DOE Solar Design Hand Book Chapter 5-V

III. Visual Aids

Storage aquastat
Solar coil limit
Three-way valve
Worksheets
Differential controller
Purge aquastat
Pumps
Thermostat
Plug-in relay
Lennox Slides 82-96
EB-Lennox Schematic Trainer or equivalent
Lennox RT-5 solar cycle trainer or equivalent

IV. Method Performance Conditions

The students, by means of review, are called upon to draw the piping of a baseline system on the blackboard. All mechanical components should be labelled. Flow patterns for basic modes of operation are discussed. The function of all electrical controls are discussed and their inter-relationships with overall flow patterns. The slides depict and highlight each of the major modes of operation. The presentation for each mode of operation should include both the mechanical and electrical systems. Trainers are interfaced to vividly display the circuitry that controls solar system operation.

V. Outline

1. Components
   - A. Mechanical
     - (1) solar system design
     - (2) modes of operation
       - a. first stage heating from collectors
       - b. first stage heating from storage
       - c. first and second stage heat from collectors and auxiliary heat
       - d. first and second stage heat from storage and auxiliary heat
       - e. second stage only
       - f. storage tank heating
       - g. purging excess heat from system
   - B. Electrical
     - (1) operation and function
       - a. differential controller
       - b. purge aquastat
       - c. storage aquastat
       - d. solar coil limit
       - e. thermostat
       - f. plug in relays
     - (2) electrical symbols
       - a. reading schematic wiring diagrams
     - (3) schematic wiring diagrams - logic system
       - a. modes of operation
         1. collectors to storage (no heat demand)
         2. first stage heat demand (from collectors)
         3. first stage heat demand (from storage)
         4. first stage heat demand (auxiliary controlled by W_1)
         5. second stage heat demand
         6. purge cycle

2. Controls - air
   - A. Control description
     - (1) modes of operation
   - B. Standard controls
     - (1) temperature control sequence of operation
     - (2) schematic
   - C. Control panel and electrical power requirements
   - D. Standard flow schematic and modes of operation

VI. Student Evaluation Parameters

1. Discuss the operating principles of a centrifugal circulating pump.
2. Discuss the operating principles of an air circulating blower.
3. Describe how the heat exchanger functions.
4. Identify the various electrical control devices used in solar heating systems.
5. Explain the functions of various hydronic specialty items used in the control of air or liquid in a solar assisted heating system.

VII. Sequence of Instruction

1. Read all reference materials.
2. View all slides and overheads of schematics.
3. Work with demonstration system, wiring up all components until all are understood.
4. Take Unit 8 quiz.
5. Take Unit 7 and 8 Examination.

AREA - SOLAR APPLICATION INSTALLATION

Unit 9 - Whole House (Installation Procedures) New and Retrofit

I. Instructional Objective

Unit nine discusses the installation of collectors, heat storage units, control devices, and specialty items. Special emphasis is placed on the scheduling of events in the sequence of activities in constructing the building. SMACNA and other organizations have established standards and guidelines for many of the installation practices used in the construction industry that apply to solar heating.

Specifications and drawings for the structure provide the manufacturer's name and model for different components in the solar heating system, as well as for the rest of the structure. Manufacturers of larger pieces of the heating equipment provide specific data for mounting and adjusting procedures for their products. The installer needs this information as do the designer and builder of the home or business being constructed.

Unit nine provides the learner with information about the sequence of events for installing liquid and air solar assisted heating equipment. These installations are discussed first for new construction and then for retrofitting an existing structure. Topics are presented in the order that they would normally occur in construction scheduling. In addition, the practice of insulating ducts and pipes at the proper time is also presented.

II. Reference Materials

Fundamentals of Solar Heating, Lesson 9
Installation Standards, Solar 5-1 & 7-1 & 8-1
Solar Decision Book, 21
Lennox Solar Volume I Installation
Installation Manual SunCell (Research Products)
Installation Manual SunPride (Revere)
Installation Manual Solaron

III. Visual Aids

Kaidib Films International Slide Series on Active Solar Installation
Lennox Solar I Slides 181-188
Field trips of existing installations and visits to installations in progress

IV. Method Performance Conditions

The students will develop a step by step procedure for installation and then perform an actual installation on a sample application.

V. Outline

I. Installation Barriers
- A. Lack of understanding by potential customers
- B. Institutional constraints (too new)
  - (1) Legal
    - a. zoning
    - b. sun rights
    - c. solar easements
  - (2) Building Codes
    - a. contact local building inspector
  - (3) Financial
    - a. restricted loans due to use of solar
  - (4) Insurance
    - a. no reluctance to insure solar

2. Array mounting variations
- A. On the top of roof
- B. Flush with roof
- C. Raised above roof
- D. Flat roof frame
- E. Ground level
- F. Lean to

3. Installation
- A. Water
  - (1) Installation check list
    - a. panel installation
    - b. protection from freezing
    - c. protection from overheating
    - d. system cleaning and charging
    - e. corrosion inhibiting
    - f. monitoring of system (log sheet)
- B. Air
  - (1) Air panel introduction
    - a. air heating unit
    - b. heat storage unit
      1. residential
      2. commercial

4. Scheduling installations
- A. Gather all material necessary to complete installation
  - (1) residential
  - (2) commercial
- B. Consider location of project and weather
- C. Sample schedule for liquid solar system new house
  - (1) storage tank placement
    - a. permits
    - b. fees
    - c. engineering
    - d. site work
    - e. excavate basement
    - f. trench footings
    - g. pour concrete
    - h. place storage tanks (NOTE: if retrofit tank will have to be welded together in existing basement and sized to fit area).

(2) Collector supports - new house
   a. floor girder
   b. frame floor
   c. subfloor
   d. frame and sheathe exterior walls
   e. set trusses
   f. fabricate collector supports
   g. sheathe roof (NOTE: on existing structure collector supports will have to be designed around present trusses).

(3) Installing collectors and plumbing new house (NOTE: leak test all components before installing on site)
   a. roof felt
   b. place collectors on roof and connect manifold
   c. roof and flashing
   d. storage piping connections
   e. storage leak test filling
   f. piping to equipment area
   g. collector and heat transport piping (pumps, valves, etc.)
   h. heat exchange piping
   i. control temperature sensors installed
   j. total plumbing leak test
      1. storage
      2. piping
      3. collector loop
      4. heat transport
      5. heat exchange
   k. insulate tank
   l. pour basement slab over tank (NOTE: retrofit storage tank will be above slab)

(4) Insulation and auxiliary heating
   a. rough electrical
   b. solar control panel
   c. rough sheet metal
   d. insulate house
   e. insulate solar piping
   f. install auxiliary heating and/or cooling system
   g. dry wall

(5) Preheat coil and control wiring
   a. preheat coil and comestic hot water tank
      1. tie in final plumbing
   b. control electrical
      1. complete wiring of main house control panel in living area
      2. complete all auxiliary and solar electrical tie ins
   c. final inspection and start up of all equipment
   d. explain to owner (operation and maintenance)

5. Sample construction schedule for air solar system new house
   A. Rock bed storage fabrication
      (1) permits
      (2) fees
      (3) engineering
      (4) site work
      (5) excavate basement
      (6) structural base for storage
      (7) trench footings
      (8) pour concrete

(9) fabricate storage container
(10) insulate storage
(11) place temperature sensors
(12) fill storage
(13) floor girders and framing (NOTE: retrofit of storage will be constructed on existing basement floor)

B. Collector supports
(1) frame and sheathe exterior walls
(2) set roof trusses on rafters
(3) fabricate collector supports
(4) sheathe roof
(5) roof felt (NOTE: retrofit - remove shingles in area collectors will cover, mount on existing roof)

C. Install collectors, heat exchanger and controls
(1) place collector on support
(2) install control sensors in collectors
(3) rough plumbing
(4) heat exchanger piping for domestic hot water
(5) rough electrical
(6) install selected solar controls

D. Ductwork - insulation and auxiliary heating and/or cooling
(1) rough sheet metal
(2) collector and heat transport ducts - dampers, blowers, heat exchangers
(3) seal air ductwork airtight (caulk)
(4) leak test ducting
(5) leak test collector loop
(6) house insulation
(7) collector duct insulate and inspect
(8) heat transfer duct insulation and inspect
(9) piping installation and inspection
(10) auxiliary heating installation (NOTE: retrofit will be tied to existing auxiliary system)

E. Preheat tank installation
(1) preheat tank and domestic hot water
(2) finish plumbing
(3) finish electrical
(4) complete all control wiring

F. Finish heating system and final inspection
(1) finish heating system
(2) operate all equipment and do final inspection
(3) explain operation and maintenance to owner

VI. Student Evaluation Parameters

1. Explain architectural problems related to installing solar heating systems.

2. Schedule and install collector arrays.

3. Schedule and install heat storage units.

4. Schedule and install controls and specialty items.

5. Schedule and install insulation

VII. Sequence of Instruction

1. Read all reference materials.
2. View all overheads and slides.
3. Visit sites.
4. Install actual system.
5. Take Unit 9 quiz.

AREA - SOLAR APPLICATION INSTALLATION

Unit 10 - Service Hot Water

I. Instructional Objectives
Step by step process to follow for installation of service hot water systems and storage (See Unit 9, same, but for DHW).

II. Reference Materials
Installation Guidelines for Solar DHW Systems
Solar Electric Hot Water Heaters (A.O. Smith)
Solar Energy Domestic Hot water System-Revere
Fundamental of Solar Heating, Lesson 8
Lennox Solar 1, Domestic Hot Water
Installations Standards Solar 19-1

III. Visual Aids
1. Overheads made from different manufacturers installation manuals.
2. Lennox Video Presentation - installation of a domestic hot water system.

IV. Method Performance Conditions
Student, by means of review, will go through roof and ground mounting procedures, installation checklist, installation tool kit.

Student will then do an entire DHW installation and evaluate the job after completion.

V. Outline
1. List of materials normally supplied by manufacturer
   A. Collector
      (1) center
      (2) right
      (3) left
      (4) trim package
   B. Blower assembly - hot water coil controls and mounting accessories
   C. Water pump
   D. Storage tank sensor
2. List of material not supplied
   A. Wood support structure/framing for installation
   B. Miscellaneous nails and screws
   C. Insulation for perimeter flashing
   D. Silicone caulk

E. Mineral spirits

F. Ductwork and accessories
   (1) flexible insulated duct
   (2) riser duct
   (3) flow adjusting dampers

G. Plumbing
   (1) storage tank
   (2) auxiliary hot water heater
   (3) 3/4" piping and fittings
   (4) swig. check valve
   (5) bleeder valve
   (6) temperature pressure relief valves
   (7) pipe insulation

H. Electrical
   (1) low voltage wire
   (2) live voltage wire

3. Tools needed and equipment

A. Conventional construction and HVAC installation tools
   (1) ¼ or 3/8 variable speed reversible drill
   (2) power saw
   (3) extension cords
   (4) scratch awl
   (5) screwdriver
   (6) hoisting harness
   (7) ladders
   (8) crane
   (9) square
   (10) chalk line
   (11) level
   (12) knife
   (13) hammer and nails
   (14) leather gloves
   (15) polarizing sunglasses
   (16) hard hat
   (17) left and right snips
   (18) hand seamers
   (19) scribe
   (20) caulk gun

4. Location of collector

A. Orientation - as close to true south as possible
   (1) compass may not give true south

B. Tilt
   (1) domestic hot water tilt is equal to latitude of region
   (2) snow cover should be considered

C. Shading factor
   (1) check for other buildings shade
   (2) trees

D. No obstruction behind collectors

5. Installation between rafters

   A. Normally done on new construction
      (1) set rafting
      (2) insert first collector, lower left corner
      (3) secure collector
      (4) fasten remaining collectors
      (5) attach sheathing around perimeter
      (6) form and install flashing (sheet metal)
      (7) seal entire collector array

6. Installation on existing roof sheating

   A. Normally done on retrofit applications
      (1) lay out array and placement of duct openings.
      (2) roofing shingles must be removed in area under collectors
      (3) cut holes in roof for duct opening
      (4) make certain duct opening is not over rafter
      (5) fabricate starter strip bottom and left side framework
      (6) install first collector lower left hand corner
      (7) fasten collector
      (8) fasten remaining collectors
      (9) top and right side perimeter framework install
      (10) form and install flashing
      (11) seal entire collector array

7. Separate support structure

   A. Same as between rafters, but frame structure must be built

8. Sealing collector array

   A. Install foam type and caulk
   B. Install trim strips
   C. Install interim trim strips (two collector high array)
   D. Perimeter trim strips
   E. Cover plate

9. Installation of duct work

   A. Manifolds and riser ducts
      (1) manifold velocity not to exceed 600 fpm
      (2) 2" insulation
      (3) silicone airtight seals
   B. Collar installation to collector and manifold
      (1) seal with silicone
   C. Sensor installation
      (1) drill hold in base of collar on uppermost center outlet opening
   D. Flexible duct connections
      (1) use manufacturers recommended flex duct only
      (2) double band and use tensioning tool

10. Installation and wiring of blower assembly

   A. Mount unit (cannot be in freezing atmosphere)

11. Storage equipment and plumbing

A. Storage tank
(1) 20 gallon per collector

B. Auxiliary water heat
(1) sized according to HUD

C. Sensor
(1) install in tee in lower side

D. Plumbing
(1) in accordance with manufacturers recommendation

VI. Student Evaluation Parameters

By completion of the installation of total DHW system (critique of quality of job demonstration).

VII. Sequence of Instruction

1. Read all reference materials.

2. View overhead and videos.

3. Install DHW system.

4. Evaluate and critique job.

AREA - SOLAR APPLICATION INSTALLATION

Unit 11 - Servicing Solar Installations

I. Instructional Objective

Unit 11 deals with the topic of servicing solar assisted heating systems. The information relates to servicing the system after equipment has been installed. Prior to this time, there may have been some testing and inspecting done during rough-in activities.

The system must first be serviced for start-up. This means that the system must be filled with water (or air), and controls must be checked to see that they operate the system properly. A check list must be completed and given to the owner that provides the properly balanced system's operating conditions. Checklists are prepared for both the liquid and the air systems as well as DHW.

Instructions are also provided for period maintenance. This is information that should be given to the owner.

There is also a need to understand troubleshooting practices for use in an emergency.

II. Reference Materials
Fundamentals of Solar Heating, Lesson Ten
Lennox Solar I Maintenance and Troubleshooting
Installation Guidelines for Solar DHW Systems 77 Maintenance
Solaron Solar Energy Systems, 600

III. Visual Aids
Use of actual operating systems
Lennox Trainer ST17 or equivalent

IV. Method Performance Objectives
Problems will be built into systems. Student will be required to follow specific maintenance and troubleshooting procedures to correct system.

V. Outline

1. Installation and maintenance checklist, air and water
2. Panel glass installation and sealing
3. Maintenance protection from freezing
4. Maintenance protection from overheating
5. System cleaning and charging

6. Corrosion Inhibiting

7. Monitoring of system and log sheet

VI. Student Evaluation Parameters

1. Discuss the general information necessary for start-up.

2. Perform the operations necessary to start-up a liquid system.

3. Perform the operations necessary to start-up an air system.

4. Identify the periodic maintenance procedures for various components of the solar heating system.

5. Explain the troubleshooting procedures for a system that needs emergency servicing.

6. Discuss maintenance problems that are common among solar heating systems.

7. Describe the purpose and extent of warranties.

VII. Sequence of Instruction

1. Read all reference materials.

2. Work with trainers and systems until maintenance and troubleshooting procedures are firmly established.

3. Take Unit 11 quiz.

4. Take Units 9, 10 and 11 Examination.

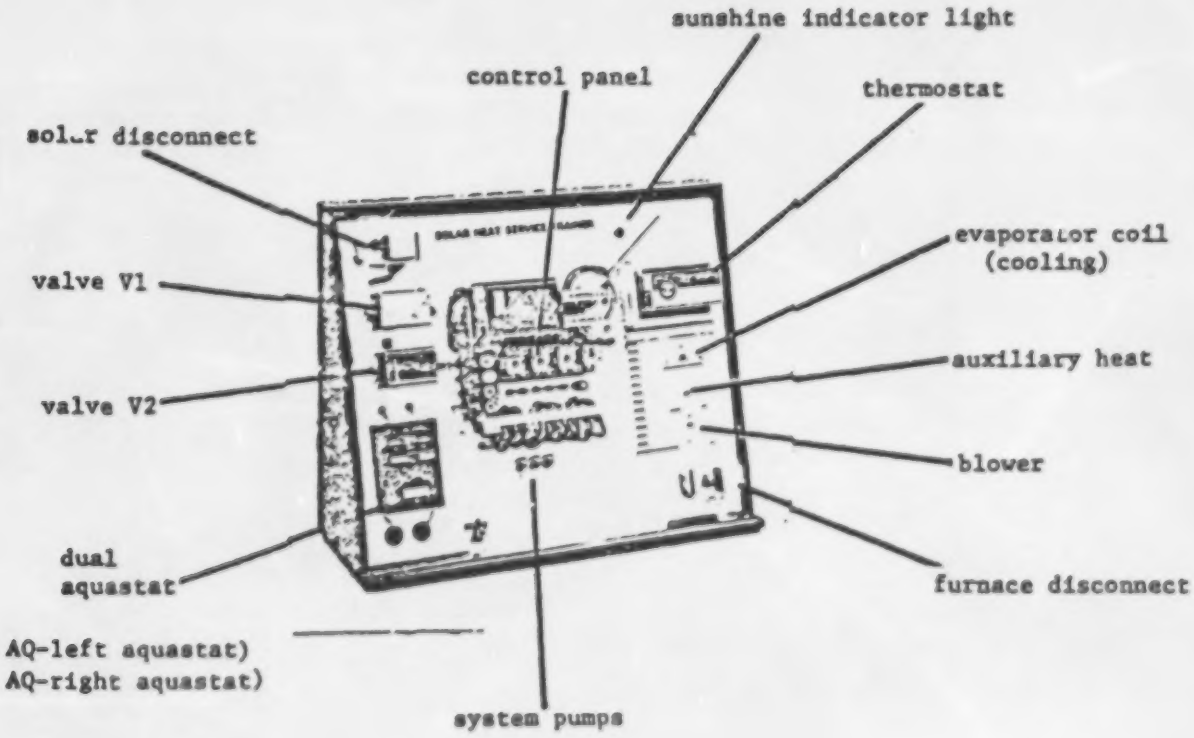
Available Lennox Corporation.

ST-17 SOLAR HEAT SERVICE TRAINER

INTRODUCTION

The ST-17 trainer is designed to teach normal operation and trouble-shooting of the electrical system for a typical solar installation. This typical solar installation has space heating and domestic hot water heating capabilities and is a 3-pump, 2-valve hydronic system (see Lennox Solar Manual for additional information on the typical solar system).

PARTS IDENTIFICATION



COMPETENCIES

The compentencies that are presented in this section have been numerically identified specifically for the major student areas of (]) Technician (2) Installer (3) Avocationist and (4) Consumer. The statements are developed with the understanding that solar systems in the State of Illinois will need to be integrated with back up systems. A knowledge of all systems is therefore necessary for a thorough understanding of the proper utilization of solar energy.

The Consumer (identified by the number 4) is interested little in the demonstration of skill but more in the lay understanding of just how a system works, its advantages and disadvantages. Their knowledges are therefore limited to the semi-technical fact in order to arrive at an educated decision when investing in a solar system.

Read and demonstrate understanding of material read at the level of a high school graduate.

Demonstrate abilities to handle mathematics at the high school graduate level.

Demonstrate an ability to communicate with others verbally and in writing at the high school level.

The Avocationist (identified by the number 3) should demonstrate the competencies of the Consumer plus:

Demonstrate physical capability and to be mechanically inclined - being able to work well with hands as well as mind.

Define basis HVACS terminology and describe theory of operation and be able to apply theory to applications.

Demonstrate an ability to read directions and apply knowledges to problem solving.

The Installer (identified by the number 2) can best be broken into sub-levels of Apprentice, Semi-skilled and Skilled.

The Apprentice Learning Level positions should be integrated educational and practical experience for the individual. The person at this point should be in direct contact with persons in the more advanced levels. In order for a person to be promoted to Semi-Skilled, he or she must meet the following criteria:

1. Define basic HVACS terminology and describe theory of operation.
2. Demonstrate basic technical skill. (Work with hand-tools, motor capabilities, etc.)
3. Demonstrate ability to work with people.
4. Demonstrate ability to follow directions.
5. Demonstrate a willingness to advance to next level. (Some people enjoy being level-one personnel--"common laborer".)

The Semi-Skilled Level should be a very short period in the career flow-pattern. This is a final polishing and coordinating of all educational and practical experiences. In order for a person to advance from this level to skilled level, the following must be demonstrated:

1. Demonstrate ability to apply theory.
2. Demonstrate problem-solving capabilities.
3. Demonstrate ability to sell people using their knowledge and understanding of components used in the field.
4. Demonstrate ability to perform more complicated tasks without excessive supervision.
5. Successful completion of higher-level technical training.
6. Demonstrate specified duration and desire to more to next step.

The Skilled Level is equivalent in salary to an upper-middle-class income level. A person reaching this level may remain and exist quite

comfortably. Anyone wishing to advance from this level must show definite drives in the following directions.

1. Demonstrate understanding of all HVACS (Heating, Ventilating, Air Conditioning and Solar Systems.)
2. Demonstrate ability to diagnose electrical, piping, equipment problems.
3. Demonstrate ability to satisfactorily complete a task without any supervision.
4. Demonstrate desire to take charge and move into next level.

The Technician (identified by the number 1) has been broken down into the levels of Specialist, Supervisory and Management.

The Specialist Level is where a person who has shown exceptional skill in a particular area, plus understanding of all other levels, can receive additional monetary and mental satisfaction for his or her expertise. Advancement from this level to Supervisory Level can be achieved by the following:

1. Demonstrate ability to analyze difficult situations critically.
2. Demonstrate ability in specific technical skills and expertise beyond Skilled Level.
3. Demonstrate, through duration of years in field and continued education, a desire to develop specific high- level skills.

Supervisory-Level personnel are persons who no longer capable of directing others from aforementioned levels to perform the job tasks. This position is approximately 50 per cent paper work and 50 per cent work-relation directionals. Anyone wishing to advance to Management Levels should be capable of achieving the following:

1. Demonstrate the ability to manage time and materials.

2. Demonstrate the ability to organize and control workflow of self and others.
3. Demonstrate the ability to communicate efficiently and effectively.
4. Demonstrate the ability to compensate for varying levels of stress on oneself.
5. Willingness to acquire position over others.

Management Level positions vary considerably. Advancement in Management Level positions is normally done through retirement or demise of Upper-Level Management persons. Years of expertise and sheer endurance may or may not cause an upper-level move. At this level, monetary compensations normally don't vary excessively from position to position. It has been determined that advancement is more politically-motivated in Management-Level structure.

1. Demonstrate ability to integrate with upper-management personnel and make definite political contact as far as direction of management.
2. Demonstrate ability to sacrifice the use of scapegoat and take full responsibility for major decisions.
3. Demonstrate ability to manage. (If going into ownership, financial and business capability should be severely scrutinized before any decisions are made.)

A. ENERGY CONSERVATION COST FOR DIFFERENT ENERGIES AND POSSIBILITY OF GOING TO ENERGY STANDARD CONSERVATION

1. Demonstrate understanding and evaluate energy conservation measures involved with heating and cooling systems.

   a. Demonstrate understanding and evaluate efficient thermostat settings for heating and cooling (night set back). (1, 2, 3, 4)

   b. Demonstrate by explaining the net comfort effects of using humidifiers and dehumidifiers to raise or lower comfort in areas. (1, 2, 3, 4)

   c. Demonstrate understanding and evaluate the use of lower heat and cooling settings for shut down or unoccupied buildings. (1, 2, 3, 4)

   d. Demonstrate familiarity with the proper fan speed for room air conditioners on humid days. (1, 2, 3, 4)

   e. Demonstrate understanding of the main contributions of internal heat gain in a building and the use of this heat gain (people, lighting, machines). (1, 2, 3, 4)

   f. Demonstrate the understanding of the purpose of maintenance and replacement schedules for system air and fuel filters. (1, 2, 3, 4)

   g. Demonstrate by explaining how cleaning HVAC air and water cooled condensors can improve operating efficiency. (1, 2, 3, 4)

   h. Demonstrate understanding of the purpose and function of a CO_2 flue gas analysis and its need for peak combustion efficiency. (1)

   i. Demonstrate understanding of the effects of insulating ductwork. (1,2,3,4)

   j. Demonstrate understanding of the effects of installing ductwork in conditioned as opposed to the unconditioned space. (1, 2, 3, 4)

   k. Demonstrate understanding of the effects of closing duct outlets in unused rooms. (1, 2, 3, 4)

1. Demonstrate understanding of the effects of improper ductwork sizing and improper location of appendaces. (1, 2, 3, 4)

m. Demonstrate understanding of the effects of zone heating and cooling. (1, 2, 3, 4)

2. Define the energy conservation measures involving outside structure walls.

a. Describe effects of thermal insulation in stud space. (1, 2, 3, 4)

b. Describe the effects of including a vapor barrier between insulation and conditioned space. (1, 2, 3, 4)

c. Describe the effects of using insulated sheathing. (1, 2, 3, 4)

d. Describe the effects of using insulated sheathing with a radiation barrier. (1, 2, 3, 4)

e. Describe the effects of unconventional framing (2 x 6 studs 24" OC, etc.). (1, 2, 3)

f. Describe the effects of adding insulated or insulating exterior siding. (1, 2, 3, 4)

3. Demonstrate understanding of energy conservation measures involving roofs.

a. Describe the effects of installation of ventilation devices in roofs or attics. (1, 2, 3, 4)

b. Describe the effects of placing a vapor barrier between the insulation and conditioned space in roof areas. (1, 2, 3, 4)

c. Describe the effects of insulating the ceiling and roof areas. (1,2,3,4)

4. Demonstrate understanding of energy conservation measures to combat infiltration in homes and commercial businesses.

a. Describe the effects of caulking around door and window casings. (1, 2, 3, 4)

b. Describe the effect of caulking under sole plates and around plumbing and electrical wiring holes in new construction. (1, 2, 3)

c. Describe the effects of weatherstripping around exterior openings. (1, 2, 3, 4)

5. Define energy conservation measures involving glazing.

a. Describe the effects of reducing glass areas on north and west sides of buildings. (1, 2, 3, 4)

b. Describe effects of storm windows. (1, 2, 3, 4)

c. Describe effects of insulating and thermal glazing. (1, 2, 3, 4)

d. Describe effect of multiple glazings. (1, 2, 3, 4)

e. Describe the pros and cons of fiberglass glazing or petrochemical glazing vs. silica-fused glazing. (1, 2, 3, 4)

f. Describe the effects of external shading (shade screens, shutters, awnings, overhead projections, bead wall). (1, 2, 3, 4)

g. Describe the effects of internal shading (draperies, blinds, roller shades, etc.) (1, 2, 3, 4)

h. Describe the effects of removable insulated panels. (1, 2, 3, 4)

6. Demonstrate understanding of energy conservation measures involving floors.

a. Describe the effects of thermally insulating exterior surfaces of concrete slab perimeters. (1, 2, 3, 4)

b. Describe the effects of insulating the inside surface of perimeter beams and insulating several feet under floor for concrete slab construction. (1, 2, 3)

c. Define the effects of closing crawl space vent openings during winter. (1, 2, 3, 4)

d. Describe the effects of thermal insulation under floors. (1, 2, 3, 4)

7. Define and evaluate energy conservation measures involved with water systems.

   a. Evaluate the installation of a pressure reducing valve in the main water supply for water systems pressurized over 40-50 lbs. (1,2,3)

   b. Describe the energy savings of using flow restrictors in water systems. (1, 2, 3)

   c. Describe the energy conservation effects of lowering temperature settings on hot water heating. (1, 2, 3, 4)

   d. Demonstrate by discussing the advantages and disadvantages of using timers on hot water heaters to turn heating elements off during periods of the day in which no hot water is needed and to allow water to be heated during off peak hours and stored for peak hour usage. (1, 2, 3, 4)

   e. Describe the need to periodically drain sediment and clay from water tanks. (1, 2, 3, 4)

   f. Explain the net energy loss from leaky faucets. (1, 2, 3, 4)

   g. Define the energy savings of using spring activated water taps. (1,2,3,4)

8. Define and evaluate energy conservation measures involved with lighting systems.

   a. Demonstrate by discussing the energy consumption, light quality, lumens per watt, the advantages and disadvantages of various lighting sources such as incandescent, flourescent, metal halide, low pressure sodium, high pressure sodium and mercury vapor lighting systems. (1, 2, 3, 4)

   b. Describe the importance of reducing wattage of incandescent bulbs when possible. (1, 2, 3, 4)

c. Be able to evaluate the rows of lights for multiple electrical switching so lights near natural light sources may be turned off when light is sufficient. (1, 2)

d. Describe the importance of regular cleaning of lighting tubes and encasements to prevent dust and dirt accumulation. (1, 2, 3, 4)

e. Describe the need to lower lights in areas with high ceilings. (1,2,3,4)

f. Describe the need to use light colored paints in lighted areas to increase reflection and reduce lighting requirements. (1, 2, 3, 4)

g. Explain the pros and cons of using mirrors, lenses, reflective coating, diffusers, polarizers, to distribute light efficiently. (1,2,3,4)

h. Be able to evaluate an area for task lighting. (1, 2, 3)

i. Define and discuss the purpose for regular lamp replacement in flourescent lighting systems and the total effect on energy consumption. (1, 2, 3, 4)

9. Demonstrate understanding of the energy conservation measures on internal electrical appliances and devices.

a. Describe the energy loss connected with ventilation fans such as range hoods and bathroom fans. (1, 2, 3, 4)

b. Define and discuss energy conservation measures in storage of refrigerated and frozen foods. (1, 2, 3, 4)

c. Define and discuss energy conservation measures when using washers and driers. (1, 2, 3, 4)

d. Define and discuss energy conservation measures in use of dishwashers. (1, 2, 3, 4)

e. Define and discuss energy conservation measures in cooking and using electrical ranges, microwaves, pressure cookers, etc. (1, 2, 3, 4)

10. Define and evaluate energy conservation measures involved in equipment purchasing and maintenance.

    a. Compute life cycle cost of equipment and evaluate the economics of purchasing based on these costs. (1, 2, 3)

    b. Evaluate the energy savings of purchasing multiple speed motors or variable speed drives for various equipment loads. (1, 2, 3)

    c. Describe the excess electrical consumption of overloaded equipment. (1,2,3)

    d. Evaluate the rewiring of major machinery from 120 volts to higher voltage and discuss how this can save energy. (1, 2, 3)

    e. Describe the need to properly lubricate-oil moving parts of equipment. (1, 2, 3, 4)

    f. Describe the need to perform preventive maintenance on equipment. (1,2,3,4

    g. Describe the purpose and energy savings of regularly cleaning electric motors from cobwebs and dust to improve efficiency. (1,2,3,4)

11. Demonstrate understanding of the energy conservation measures of fireplaces.

    a. Describe the net heating effect of fireplaces taking into account the air and combustion requirements. (1, 2, 3, 4)

    b. Describe combustion requirements for fires. (1, 2, 3, 4)

    c. Describe the effects of combustion air ducts (internal and external). (1, 2, 3)

    d. Describe the effects of air infiltration and fireplaces. (1, 2, 3, 4)

    e. Describe the effect of sdaled doors on a fireplace. (1, 2, 3, 4)

12. Demonstrate understanding of the energy conservation effects of other miscellaneous measures.

    a. Define the proper clothing requirements to save energy during heating and cooling periods. (1, 2, 3, 4)

    b. Describe the effects of deciduous shading in summer and winter. (1, 2, 3, 4)

B. INTRODUCTION TO SOLAR ENERGY AND EMERGING ENERGIES

1. Define historical aspects of solar energy.

   a. Ancient uses and methods of converting solar energy. (1, 2, 3)

   b. Go over mistakes made in the past that we have learned from. (1, 2, 3)

2. Demonstrate understanding of current solar technology.

   a. Active and passive solar energy systems. (1, 2, 3, 4)

   b. Practical applications and proven hardware and conversion methods (domestic hot water, space heating, swimming pool heating, space cooling, and agricultural and industrial applications). (1, 2, 3, 4)

3. Describe emerging solar techniques, applications, and developments.

   a. Comprehend theory of the following (solar photovoalatic cells, space power stations, microwave transmissions, solar farms, and sea thermal energy). (1, 2, 3, 4)

4. Demonstrate understanding of other current and projected sources of energy (pros and cons).

   a. Nuclear fusion (1, 2, 3, 4)

   b. Nuclear fission (1, 2, 3, 4)

   c. Coal Technology (burning, gassification, liquidification). (1, 2, 3, 4)

   d. Petrleum distillates and by-products (1, 2, 3, 4)

   e. Natural gas (1, 2, 3, 4)

   f. Shale oil (1, 2, 3, 4)

   g. Methane-biogas (1, 2, 3, 4)

   h. Tar sands (1, 2, 3, 4)

   i. Wind (1, 2, 3, 4)

   j. Wood (Pellets, fluidized beds-gassification) (1, 2, 3, 4)

   k. LNG (1, 2, 3, 4)

   l. Geopressurized gas (1, 2, 3, 4)

   m. Geothermal (1, 2, 3, 4)

n. Biomass and alcohol conversion (1, 2, 3, 4)

o. Wave (1, 2, 3, 4)

5. Describe United States and world energy demands vs. supplies. (1, 2, 3, 4)

6. Describe United States energy situations and move for energy independence. (1, 2, 3, 4)

7. Describe current status of solar industry (manufacturers and manpower needs). (1, 2, 3, 4)

8. Describe the United States balance of trades and the effect petroleum purchasing has on this balance. (1, 2, 3, 4)

C. SOLAR RADIATION

1. Describe the physical characteristics of the sun (size, temperature, distance from the earth, reusable energy). (1, 2, 3, 4)

2. Demonstrate understanding of the factors affecting the path of radiation through the atmosphere. (1, 2, 3, 4)

a. Angle of incidence (latitude, time of year, time of day). (1, 2, 3, 4)

b. Altitude (1, 2, 3, 4)

3. Demonstrate understanding of the physics of radiation reaching the earth's atmosphere.

a. Understand the time factor. (1, 2, 3, 4)

b. Understand the solar radiation constant. (1, 2, 3, 4)

c. Understand physics of solar radiation and light (ultraviolet, visible, and infrared). (1, 2, 3, 4)

4. Describe the physics of radiation reaching the earth's surface.

a. Characteristics of direct vs. diffuse radiation. (1, 2, 3, 4)

b. Factors affecting diffusion of direct radiation (moisture, clouds, haze, dust, smog, etc.). (1, 2, 3, 4)

5. Describe the average daily radiation and the waather service charts depicting this information, how to read and interpret. (1, 2, 3)

6. Define the factors affecting the proper collector tilt (solar noon, azimuth angle, sun altitude). (1, 2, 3)

D. SOLAR ENERGY SYSTEM DESIGN

1. Describe the arrangement of equipment, ductwork, piping, and operating control modes for liquid systems.
   a. Domestic hot water only. (1, 2, 3)
   b. Space heating and domestic hot water. (1, 2, 3)
   c. Space heating, domestic hot water, and swimming pool heating. (1, 2, 3)
   d. Space heating, space cooling, and domestic hot water. (1, 2, 3)
2. Describe the arrangement of equipment, ductwork, piping, and operating control modes for liquid systems with freeze protection (heat exchangers, drain down, pump pulse). (1, 2, 3)
3. Describe the arrangement of equipment, ductwork, piping, and operating control modes for air systems.
   a. Domestic hot water air system. (1, 2, 3)
   b. Domestic hot water and space heating system. (1, 2, 3)

E. COLLECTORS

1. Demonstrate understanding of the pros and cons of the various types of collectors.
   a. Flat plate types (air, liquid, evacuated tuve). (1, 2, 3)
   b. Concentrating types (parabolic, parabolic trough, stationary reflector tracking absorber, fernel lens, and heliostats). (1, 2, 3)
   c. Photovotaic cells. (1, 2, 3)
2. Demonstrate the applications of collectors and the best type of collector for specific purposes. (1, 2, 3)
3. Define the basics of collector performance.
   a. Define variables affecting energy absorbed by the collector such as incident radiation on collector surface, transmissivity of glazing, and absorber variables. (1, 2, 3)

b. Demonstrate understand of the heat losses of collectors (conduction, radiation, convection) and the losses from various parts of the collector. (1, 2, 3)

c. Perform experiments to emphasize the effect of collector glazing and heat loss (single vs. double glazing). (1, 2, 3)

4. Describe the use and purpose of collector components. (1, 2, 3, 4)

F. SOLAR AIR SYSTEMS

1. Define the various types of metal and fiberglass ductwork and the pros and cons of each type. (1, 2, 3)

2. Describe the purposes of insulating air distribution systems for both thermal and sound control. (1, 2, 3)

3. Describe the purpose of a good air distribution system. (1, 2, 3)

4. Describe the purpose of various air system supply and return devices such as registers, grilles, and diffusers. (1, 2, 3)

5. Define the dampers and damper motors used in air systems. (1, 2, 3)

6. Define various parts of air distribution systems that resist air movement such as heat storage units, coils, filters, registers, grilles, diffusers, and ductwork. (1, 2, 3)

7. Defind types of centrifugal fans and their performance criteria (forward curved, radial, and backward curved). (1, 2)

8. Demonstrate use of airflow meters and temperature controls used in air systems. (1, 2)

G. SOLAR HYDRONIC

1. Demonstrate the types of pumps, their selection and purpose in application to hydronic systems, sizing very important. (], 2)

2. Define the types of pipes and fittings used in hydronic systems. (1, 2, 3)

3. Descrive the purpose of the various valves used in hydronic systems. (1, 2, 3)

4. Demonstrate the understanding of various types of heat exchangers used in hydronic systems and the selection criteria for each type. (1, 2, 3)

5. Describe the purpose for expansion tanks in a hydronic system and be familiar with the various types of expansion tanks, their locations, and the sizing criteria. (1, 2)

6. Describe the purpose of other accessories in a hydronic system such as air vents, strainers, balancing valves, regulators, pressure and temperature relief valves, vacuum relief valves, etc. (1, 2)

7. Demonstrate being familiar with flow, pressure, and temperature instruments used in hydronic systems. (1, 2)

H. HEAT EXCHANGERS

1. Explain the purpose and function of air type and water type heat exchangers. (1, 2, 3)

2. Explain the construction and pros and cons of the following types of heat exchangers; shell and tube, shell and double tube, double wall, and parallel tube heat exchanger. (1, 2, 3)

I. STORAGE

1. Explain the pros and cons of the various heat storage methods (liquid, solid, phase change, Eutectic salts). (1, 2, 3)

2. Describe latent heat and sensible heat and examples of storage medium utilizing these methods. (1, 2, 3)

3. Explain the purpose of insulating storage areas. (1, 2, 3)

4. Define the various materials used to construct heat storage systems. (1,2,3)

J. SOLAR ENERGY COOLING

1. Describe the theory and define system components of the Triethylene Glycol open cycle system. (1, 2, 3)

2. Describe the theory and define system components of the absorption system cooling basic cycle. (1, 2, 3)

3. Describe the theory and define system components of the rankine cycle vapor compression system. (1, 2, 3)

4. Describe rock bed evaporative cooling and radiative cooling. (1, 2, 3)

K. SOLAR ENERGY CONTROLS

1. Demonstrate the purpose, construction and operation of a relay. (1, 2)

2. Demonstrate the purpose, construction, and operation of a low voltage transformer. (1, 2, 3)

3. Demonstrate the purpose, construction and operation of an electrically powered solenoid valve. (1, 2, 3)

4. Demonstrate the purpose, construction, and operation of an electrically powered multi-blade damper. (1, 2, 3)

5. Demonstrate the purpose, construction and operation of various controls used to activate component parts of a solar energy system (two stage low voltage thermostate, outdoor thermostate, differential controller, outdoor reset controller). (1, 2, 3)

6. Demonstrate the purpose, construction, and operation of various sensors used to initiate electrical impulses (bimetal sensor, bellows/diaphram sensor, thermistor sensors.) (1, 2, 3)

L. BLUEPRINT READING

1. Demonstrate ability to interpret architectual drawings and specifications. (1,2,3)

2. Demonstrate ability to determine equipment sizings from architectural drawings. (1, 2, 3)

3. Define, interpret and understand isometric and 3-view machine drawings. (],2,3)

4. Demonstrate ability to sketch pictorially.(1,2)

5. Demonstrate methods of sketching in proportion. (1,2)

M. HEAT LOSS/HEAT GAIN CALCULATIONS

1. Calculate the residential heating and cooling loads using the ASHRAE residential procedure or NESCA or IBR and the utility and manufacturers company short form methods. (1,2)
2. Review the ASHRAE procedures for calculating heating and cooling loads for commercial buildings. (1,2)

N. SAFETY

1. List the six classifications of accidents in the HVAC shop (mechanical causes, electrical shocks, high pressure, burns and scalds, explosions, and breathing toxic gases). (1, 2, 3)
2. Demonstrate understanding of electrical safety rules.
   a. Major causes of electrical accidents. (1, 2, 3)
   b. Safety rules for using electrical tools and test equipment (1, 2, 3)
   c. Electrical rescue procedures and first aid. (1, 2, 3)
3. Define refrigerant safety rules and proper storage and handling procedures. (1, 2, 3)
4. Describe safety precautions for handling gas and pressurized refrigerant cylinders. (1, 2, 3)
5. Define safety precautions using the highly flammable gases used in the trade (propane, propylene, ethane, ethylene, methane, isobutane, acetylene). (1, 2, 3)
6. Define safety rules for using air acetylene and oxacetylene torches. (1,2,3)
7. Define safety precautions for handling large pieces of glass. (1, 2, 3)
8. Define safety rules involving fire and its hazards.
   a. The fire triangle (1, 2, 3, 4)
   b. Classes of fires and the type of extinguisher used to contain these fires. (1, 2, 3, 4)

9. Define rules for general shop safety. (1, 2, 3)

10. Define the steps and procedures to maintain a clean and orderly shop. (1, 2, 3)

11. Define the steps to follow in case of an accident in the shop. (1, 2, 3)

12. Describe personal safety rules involving clothing, personal hygiene, and conduct. (1, 2, 3)

13. Define steps for lifting heavy objects. (1, 2, 3, 4)

14. Define safety rules related to working on pitched roofs. (1, 2, 3)

15. Define safety rules for using ARC welding equipment. (1, 2, 3)

16. Demonstrate federal safety colors and applications of the safety color code. (1, 2, 3)

17. Define all OSHA rules pertaining to heating, air conditioning, ventilating trades. (1, 2, 3)

O. INSTALLATION (SOLAR ENERGY)

1. Verify large/small system, read installation manual. (1, 2, 3)

2. Mount and install major items.

a. Install auxillary conventional furnace (see HVAC Competencies). (1, 2)

b. Install domestic hot water tank (water systems) (1, 2)

c. Install and connect pipe to the following hydronic components (hydronic systems). (Heat exchangers - liquid to liquid and air to air to liquid; pumps, expansion tanks, air vents; strainers; balancing valves; regulators; pressure and temperature relief valves; control valves; flow; temperature and pressure sensors and meters; thermal insulators; vacuum relief valve). (1, 2)

Install the following air distribution components (air systems): (ductwork, sheetmetal and fiberglass, see air distribution;

competencies; supply and return devices, registers; grilles; and diffusers; thermal and sound insulation; blowers; water to air heat exchangers; piping.

d. Flush, fill and purge hydronic systems. (1, 2)

Insulate pipes or ductwork.

3. Install collectors

a. Shop test all components for leaks before assembly. (1, 2)

b. Prepare/construct collector mounting foundation (roof or free standing), and check and wind leads. (1, 2)

c. Construct and install collector mountings. (1, 2)

d. Mount collectors (1, 2)

e. Install collector temperature sensors. (1, 2)

4. Construct/install storage system.

a. Check tank for leak. (1, 2)

b. Insulate storage container. (1, 2)

c. Prepare foundation. (2)

d. Install or construct storage or preheat container (liquid and/or rock). (2)

e. Install internal container components (rocks, heat exchangers). (2)

f. Install storage temperature sensors. (1, 2)

g. Construct connections to system (air and water). (1, 2)

5. Install and connect electrical controls and wire the total system.

a. Make electrical connections to the following: controls; thermostats; sensors; pumps; blowers, auxiliary heating; control valves and dampers. (1, 2)

b. Install thermostats. (1, 2)

c. Install main controls. (1, 2)

d. Install remaining sensors. (1, 2)

e. Connect to main control panel. (1, 2)

f. Possible micro-process to handle wiring diagram-programming. (1, 2)

6. System checkout and startup.

a. Perform visual inspection of overall system. (1, 2)

b. Check placement of sensors, control devices, and wiring. (1, 2)

c. Check equipment for proper position, support, and service access. (1, 2)

d. Pre-test clean and flush. (1, 2)

e. Start up system to perform other checkout procedures. (1, 2)

f. Check the following for hydronic systems: solution charge, antifreeze or solution concentration, flow rates, pressures, operation of safety valves, leaks. (1, 2)

g. Check the following for air systems: leaks, flow rates, damper operation. (1, 2)

h. Fine tune the system for peak performance. (1, 2)

i. Check system performance with actual design criteria. (1, 2)

j. Make customer aware of how to operate system. (1, 2)

P. EVALUATING SOLAR ENERGY SYSTEM PERFORMANCE

1. Measure various system temperatures using thermometers, thermocouples, thermistors, etc. (1)

2. Use an insulation meter to measure solar energy available at collector surface. (1)

3. Use a velometer, pitit-tube and manometer, anemometer, etc. to measure air flow. (1)

4. Determine air density by measuring with a dry bulb, wet bulb. (1)

5. Use a flow meter to measure liquid flow. (1)

6. Measure liquid density with hydrometer. (1)

7. Evaluate system performance from measured data. (1)

Q. MAINTENANCE (SOLAR SYSTEM)

1. Perform routine maintenance of solar energy systems.

   a. Check condition and operation of all system components. (1, 2, 3)

   b. Check tracking orientation of concentrating collectors. (1, 2, 3)

   c. Replace system components which are periodically consumed. (1, 3)

   d. Flush storage tanks to remove dediment. (1, 3)

   e. Descale heat exchangers (water side). (1, 3)

   f. Check fluid levels, flow rates, and solution concentrations (flush and refill if necessary). (1, 3)

   g. Lubricate moving parts. (g)

   h. Check motor belts for tension and alignment. (1, 3)

   i. Change or clean all filters. (1, 3)

   j. Check and adjust air flow through air handling unit. (1, 3)

   k. Check controls, wiring, and proper mechanical operations in various modes. (1, 3)

   l. Check glazing to be sure it is free from obstructions (paper, glass, dirt). (1, 3)

   m. Check condition of insulation (piping, storage, ductwork). (1, 3)

R. TROUBLESHOOTING AIR SOLAR SYSTEM

1. Troubleshoot system that has no air flow.

   a. Check blower motor for power (1)

   b. Check blower vains clean. (1)

   c. Check duct work connections (1)

   d. Check collector (1)

2. Troubleshoot erratic operating systems.

   a. Check main regulating panel for proper installation of sensors and settings on controllers. (1)

b. Check all dampers for proper operation. (1)

c. Check all back-up systems for proper operation. (1)

3. Troubleshoot for lack of enough hot air.

a. Check collectors for proper facing and angle. (1)

b. Check controls for proper sensing and function. (1)

c. Check storage for proper damper positioning. (1)

d. Check for proper size storage and insulation. (1)

e. Check duct work for heat loss. (1)

f. Check air flow for proper movement rate and pressure. (1)

4. Troubleshoot system with decreasing performance.

a. Check collector fir dirt, deterioration, absorber coating, cracks, bad seals, increased shading. (1, 3)

5. Troubleshoot for noisy system.

a. Check for air leaks in ductwork. (1, 3)

b. Check for proper lubrication of all components. (1, 3)

c. Check fan speed and belt adjustment and newness. (1, 3)

S. TROUBLESHOOTING HYDRONIC SOLAR ENERGY SYSTEMS

1. Troubleshoot systems that are frequently not in operation or in continuous operation.

a. Check differential thermostats for proper setting, installation, and mechanical or electrical operation. (1)

b. Check sensors for proper installation and electrical operation. (1)

2. Troubleshoot solar systems that have no fluid flow.

a. Check pump to see if the impeller is bound. (1)

b. Make sure shutoff valves are working properly. (1)

c. Check flow regulator for obstructions or improper installation. (1)

d. Inspect system to see if it is air locked. (1)

e. Check pump installation. (1)

f. Inspect system for the proper number of vents. (1)

3. Troubleshoot various system components for the problem of lack of enough hot water.

a. Check collectors for improper face or slope, shade, insufficient design area, and unequal flow. (1)

b. Check differential thermostate for electrical connections, sensor locations, sensor mountings, faulty sensors, or faulty thermostats. (1)

c. Check the mixing valve for proper mechanical operation or improperly set temperature indicator. (1)

d. Check storage tank for size, electrical connections, storage heat loss. (1)

e. Check piping for heat loss. (1)

4. Troubleshoot solar systems for decreasing performance.

a. Check collectors for dirt, deteriorating absorber coating, cracks, detericrating seals, or increased shading. (1, 3)

b. Check storage tanks for sludge. (1, 3)

5. Troubleshoot solar systems for excessive noise.

a. Check to make sure the system is not air locked. (1)

b. Check piping for trapped air. (1)

c. Check air purger for proper installation and operation. (1)

d. Check air vents for proper operation. (1)

6. Troubleshoot various system components for the problem of water leaks.

a. Check fittings at all locations. (1)

b. Check manufacturer collectors for leaks. (1)

c. Check pump bearing assembly. (1)

7. Troubleshoot solar systems for pressure drops.

   a. Check pressure in the expansion tank. (1, 3)

   b. Check relief valves. (1)

   c. Inspect for slow leaks in collectors and system piping. (1)

   d. Check air vents. (1,3)

   e. Check storage tank for a leak in the heat exchanger. (1, 3)

Other necessary knowledge to perform properly on total system.

AA. INSULATION

1. Describe the basic principles of heat transfer (conduction, convection, radiation.) (1, 2, 3, 4)
2. Review, discuss, and demonstrate an understanding of insulating values, terms, and heat loss coefficients (BTU, U, R). (1, 2, 3)
3. Describe the proper areas of a structure to insulate and be familiar with minimum R values for energy conservation. (1, 2, 3)
4. Define the pros and cons of various insulating materials.

   a. Describe loose fill insulation such as rock and glass wool, wood pulp products, and vermiculite. (1, 2, 3)

   b. Describe blanket and batt flexible insulation. (1, 2, 3)

   c. Describe rigid insulation such as fiberboard, building boards, wall boards, sheathing, and expanded polystyrene and urethane plastic foams. (1, 2, 3)

   d. Describe reflective insulation such as aluminum foil, sheet metal with reflective coating, and paper products coated with reflective oxide composition. (1, 2, 3)

5. Define the principles and purpose of vapor barriers and be familiar with condensation resulting from these barriers. (1, 2, 3)
6. Demonstrate proper installation procedures for various types of insulation. (1, 2, 3)

BB. TOOLS USED IN THE HVAC TRADE

1. Identify, demonstrate the proper use and care for general hand tools used in the HVAC trade.

   a. Identify and demonstrate the proper use of the following general hand tools: screwdrivers, wrenches, pliers, hammers, chisels, punches, bars, files, socket sets, tubing tools, threading tools, and accessory hand tools used in the HVAC trade, and sheet metal tools. (1, 2, 3)

2. Identify, demonstrate the proper use and care for specialized tools used in the HVAC trade.

   a. Identify and demonstrate the proper use of a refrigeration gauge set for charging, evacuating and checking pressures. (1, 2)

   b. Identify and properly use fin combs and the following sheet metal tools: combination and pattern snips, hand notcher, hand seamer, riveting and other hammers, right and left hand aviation snips, double cutting snips, hand crimper, dividers, drive turner, scratch awl, break, shear and pitsburg. (1, 2, 3)

   c. Identify and select drill bits for wood, masonry and metal. (1, 2, 3)

   d. Identify and properly use a bench vise and a pipe vise. (1, 2, 3)

   e. Identify and properly use wheel, bearing, and gear pullers. (1, 2, 3)

   f. Identify and state the use of pocket, remote bulb, flue and stack, and thermal thermometers. (1, 2)

   g. Identify and properly use a refrigeration ratchet. (1, 2)

   h. Identify and demonstrate the proper use of an electric recording thermometer. (1, 2)

   i. Identify and demonstrate the proper use of the following hygrometers; sling psychrometer, dial type hygrometer and humidity recorder. (1, 2)

j. Identify and demonstrate the use of a low and a high vacuum pump triple and deep. (1, 2)

k. Identify and properly use the following vacuum indicators: compound gauge, mercury manometer, and thermocouple micron gauge. (1, 2)

l. Identify and properly use the following air meters: aneometer, pilot tube, and incline manometer. (1, 2)

m. Identify and properly use a combusion testing kit. (1)

n. Identify and properly use electronic and halide leak detectors. (1)

o. Identify and properly use electrical hand tools, wire strippers, kleins, conduit bender, water pump pliers. (1, 2, 3)

3. Identify, properly use, read, and care for measuring instruments used in the HVAC field.

a. Identify, use, read, and care for rules used in the HVAC trade (combination square, folding rule, steel rule, circumferencr rule, steel tape), metric. (1, 2, 3)

b. Identify, properly use, read, and care for wire and drill gauges used in the HVAC trade. (1, 2, 3)

c. Identify, use, and care for slide, inside and outside calipers used in the HVAC trade. (1, 2)

d. Identify, read, use, and care for inside and outside micrometers used in the HVAC trade. (1, 2)

e. Identify, read, use and care for charging cylinders for measurement of fluorohydro carbons. (1)

CC. TUBING AND PIPING

1. Demonstrate an ability to distinguish between different types of tubing and fittings, and select the proper size and type of tubing and fittings needed for a particular application. (1, 2)

a. Describe the various uses of copper, aluminum, steel, and glass tubing. (1, 2, 3)

b. Define the difference between nominal size copper tubing and ACR copper tubing. (1, 2)

c. Define the difference between annelled and hard drawn copper tubing and state the proper use of each type. (1, 2)

d. Describe the classification, specifications, and proper use of copper tubing in relation to wall thickness (K, L, M, DWV). (1, 2, 3)

e. Explain the use and identify the various types of fittings and valves for flare connections, compression connections, and sweat connections, swedge, threaded, epoxy. (1, 2, 3)

f. Identify various flare and splice hose fittings. (1, 2, 3)

g. Identify cutter type and spring loaded seal quick connect fittings. (1, 2, 3)

h. Describe the construction and use of flexible refrigerant hose. (1, 2, 3)

2. Demonstrate the skill to properly use the tools and processes to cut, flare, bend, and swage tubing within various specifications.

a. Identify and demonstrate the proper use of a tubing cutter and reamer. (1, 2, 3)

b. Demonstrate the ability to double and single flare a tube using a compression type flaring block. (1, 2)

c. Demonstrate the ability to make a swage joint using a hand swage set and mechanical set. (1, 2)

d. Demonstrate the ability to use an inside and outside spring type bender and a lever type bender to bend a 90° bend, a 180° bend, and a 45° offset bend. (1, 2)

3. Describe the HVAC uses of black iron, galvanized, and plastic pipe, and the fittings used with these pipes and be able to select the

proper type and size of pipe and fittings to serve in a particular application.

a. Define the uses of galvanized pipe in the HVAC trade and identify various fittings for iron pipe. (1, 2)

b. Define the uses of black iron pipe in the HVAC trade and identify various fittings for iron pipe. (1, 2)

c. Describe sizing specifications for black iron and galvanized pipe such as standard wall, extra strong wall, and double extra strong wall. (1, 2)

d. Define the use of cast iron fittings in hydronic heating. (1, 2)

e. Describe the difference and the application pros and cons of the four types of plastic pipe (ABS, PVC, CPVC, and PE). (1, 2)

f. Define the advantages and disadvantages of using plastic pipe in the HVAC trade. (1, 2)

g. Identify the various fittings for ABS, PVC, and CPVC pipe. (1, 2)

h. Identify the various fittings for flexible plastic pipe . (1, 2)

4. Demonstrate the skill and ability to size, cut, thread, and assemble black iron and galvanized pipe.

a. Demonstrate the ability to cut iron or galvanized pipe using a wheel type cutter, ream the burs from the inside of the pipe using a spiral type reamer, and use a die stock and proper size die to thread the pipe. (1, 2)

b. Assemble the threaded pipe in the proper fitting using the proper pipe wrenches and proper thread sealant. (1, 2)

5. Demonstrate the skill and ability to size, cut, ream and assemble plastic pipe using insert fitting joints and solvent joints. (1, 2)

DD. SOLDERING, BRAZING AND WELDING

1. Demonstrate an understanding of safety rules when soldering, brazing and welding. Name and discuss the component parts of the air-propane torch, air-acetylene torch, high and low velocity, oxyacetylene torch, and the electric welder, and be able to light and adjust the air propane torch, air-acetylene torch, and the oxyacetylene torch.

   a. Describe the purpose for, and safety equipment needed for, using gas welding and soldering equipment. (1, 2, 3)

   b. Define the purpose for, and safety equipment needed for, using electric welding equipment. (1, 2, 3)

   c. Identify the components, assemble, and state the purpose of the air-acetylene torch, high and low velocity. (1, 2, 3)

   d. Identify the components, assemble, and state the purpose of the air-propane torch. (1, 2, 3)

   e. Demonstrate the skill to safely light, adjust, and extinguish both the air acetylene torch and the air propane torch. (1, 2, 3)

   f. Demonstrate the skill to safely light, adjust and extinguish the halide leak detector. (1, 2)

   g. Describe the proper cleaning procedure and care of the air acetylene and the air propane torch. (1, 2)

   h. Identify, assemble, and state the purpose of the components of the oxyacetylene torch. (1, 2)

   i. Demonstrate the skill to safely light, adjust and extinguish the oxyacetylene torch. (1, 2)

   j. Demonstrate the proper cleaning procedure and care of the oxyacetylene torch. (1, 2)

   k. Identify the components and state the purpose of the electric welder in climate control. (1, 2)

1. Demonstrate the proper cleaning procedure and care of the electric welder. (1, 2)

2. Demonstrate an understanding of types of soft solder and fluxes and demonstrate the proper skill and procedure to soft solder various types of swage joints.

   a. Define the purpose of cleaning and fluxing a solder joint and understand the pros and cons of fluxes (corrosive paste flux, and liquid self-cleaning flux). (1, 2)

   b. Demonstrate the proper use and explain the pros and cons of various sypes of soft solders (50-50, 95-5). (1, 2)

   c. Escribe the purpose of capillary action in a solder joint and the conditions and methods to create capillary action. (1, 2)

   d. Clean, flux, and solder the following joints using the air propane or the air acetylene torch: swage joint, inverted swage joint, horizontal swage joint. (1, 2)

   e. Clean, flux, braze, and solder a swage joint with the oxyacetylene torch. (1, 2)

3. Demonstrate an understanding of the types of silver brazing alloys and fluxes and demonstrate the proper skill and procedure to silver braze various types of swage joints.

   a. Define the types of characteristics of the different silver brazing alloys (AWS BAg-1, AWS BCuP-5, AWS BCuP-3). (1, 2)

   b. Describe the purpose of cleaning and borax fluxing a silver brazing joint and the purpose of cleaning the joint after soldering. (1, 2)

4. Demonstrate the process of oxyacetylene cutting.

   a. Adjust and extinguish the cutting torch. (1, 2)

   b. Make the following cuts on mild steel: straight lines, 90° turns and holes. (1, 2)

5. Demonstrate the process of oxyacetylene brazing and welding.

   a. Adjust and extinguish the oxyacetylene welding torch. (1, 2)

   b. Weld beads on plate without filler rods. (1, 2)

   c. Weld beads on plate with filler rod. (1, 2)

   d. Weld joints in different positions with filler rod. (1, 2)

6. Demonstrate the process of bronze braze welding.

   a. Identify the principles of bronze brazing. (1, 2)

   b. Braze weld a square edge joint in any position. (1, 2)

7. Describe the principals of ARC welding.

   a. Identify and describe the parts and function of the electric arc welding unit. (1, 2)

   b. Identify and select electrodes properly. (1, 2)

   c. Set up, adjust and shut down the arc welding unit. (1, 2)

   d. Strike and maintain an arc. (1, 2)

8. Demonstrate arc welding procedures.

   a. Make a pad in the flat position. (1, 2)

   b. Make a pad in the horizontal position. (1, 2)

   c. Make a multiple pass T-joint fillet weld in the horizontal position. (1, 2)

EE. SHEET METAL

1. Discuss the manufacturing processes, properties, and varieties of metals used in the sheet metal trades. (1, 2)

2. Demonstrate skill in using sheet metal hand tools.

   a. Demonstrate the proper use of measuring and marking tools. (1, 2)

   b. Demonstrate the proper use of bench tools. (1, 2)

   c. Demonstrate the proper use of sheet metal cutting tools. (1, 2)

   d. Demonstrate the proper use of joining tools. (1, 2)

3. Demonstrate proper procedure for joining sheet metals using fasteners, seams and joints.

   a. Basic fitting layout. Emphasis is placed on various types of seams, elbows and ducts. (1, 2)

4. Detail involved in fitting layout. Triangulation used in construction of various square and round fittings. (1, 2)

5. Emphasis is placed on short cuts in triangulation. Development of proper bench procedures needed in sheet metal layout. (1, 2)

6. Fitting-layout with emphasis on proper area for air distribution needed in air conditioning. Fitting and duct to first be designed by use of the trane ductalator. (1, 2)

7. Designing a ventilation system for a residential or small commercial installation. Emphasis will be placed on grill placement and proper duct sizing. (1, 2)

8. Demonstrate skills and proper procedures in using sheet metal machines (shears, bar boulder, slip and roll forming machines, hand brake, and box and pan brakes, and metal seaming machines. (1, 2)

FF. FUNDAMENTALS OF ELECTRICITY

1. List specific safety rules in the electricity area (fire, poison, electrocution).

   a. Define general safety rules in the electrical shop. (1, 2, 3)

   b. Demonstrate first aid procedures for shock victims. (1, 2, 3)

2. Explain the electron theory as it relates to electricity and distinguish between static and current electricity.

   a. Discuss how static electricity is used in the climate control trade (electrostatic air cleaners and refrigerator capacitors and condensors). (1, 2)

b. Discuss the two kinds of current electricity and the electron movement involved (AC and DC), generators, alternators. (1, 2)

3. Describe the different measurements and terms associated with electrical power. Discuss transformer theory.

a. Define voltage and the various types of voltage (applied or source voltage, voltage rating, voltage drop). (1, 2)

b. Define the meaning of ampere. (1, 2)

c. Define the meaning of ohm and the variables that affect resistance. (1, 2)

d. Define the meaning of the coulomb. (1, 2)

e. Define the meaning of the term watt and review watts law for DC power. (1, 2)

f. Define the meaning of the term horsepower. (1, 2)

g. Describe the various munerical prefixes (mili, micro, kilo, mega). (1, 2)

4. Describe the six methods of producing electricity, cite examples of each, and discuss the type of current produced (friction, heat, light, pressure, chemical action, mechanical motion).

a. Define the basis of producing electricity with mechanical motion (conductor + magnetic field + movement = voltage). (1, 2)

b. Describe the principles of producint electricity with heat and the operation of a thermocouple. (1, 2)

c. Describe methods of producing mechanical motion - fossil, solar, nuclear, gravitational, geothermal. (1, 2)

d. Perform experiments in production of electricity in some of the methods of producing electricity (1, 2)

5. Identify and work problems using Ohms law to compute voltage, current, and resistance. (1,2)

6. Describe the various materials and types of materials that will not transmit electricity (nonconductors), glass, rubber, plastic, wood, ceramic and mica). (1,2)

7. Describe the various materials and types of materials used to transmit electricity (conductors).

   a. Define the four main materials for wire and the relative conductivity (silver, copper, gold and aluminum). (1,2)

   b. Define the conductors of electricity (silver, coppper, gold, aluminum, tungsten, zinc, brass, platinum, iron, nickel, tin, steel, lead, mercury, nichrome). (1,2)

   c. Define the pros and con s of solid wire vs. stranded wire and state the conditions of use for each of these types of wire. (1,2)

   d. Define the various types of wire coverings and the advantages and disadvantages of each under certain conditions. (1,2)

   e. Demonstrate the flow of electrons through various sizes of wire (gauge). (1,2)

   f. Describe the principles, materials, and use of resistance wire and discuss resistance wire in electrical heating elements. (1,2)

8. Define the various semiconductors of electricity and their place in solid state electronics. (1,2)

9. Demonstrate the use of electrical resistors (semiconductors) in electronic circuits.

   a. Define the types and use of fixed resistors. (1,2)

   b. Define the types and use of variable resistors (potentiometers, rheostats, and trimmer resistors). (1,2)

c. Compute resistor values and tolerances using a meter and color code. (1,2)

d. Demonstrate the types and uses of thermistors (negative coefficient type - NTC, and positive temperature coefficient type - PTC, used in temperature operated electric circuit control, to measure temperatures, and to stop electric power flow to a motor if the whindings temperature increases. (1)

10. Define the purpose of capacitors used in the climate control trade. (1,2)

11. Describe the purpose of other electrical components used in the climate control trades (diodes, rectifiers, transistors, sensors, amplifiers, transducers, transformers, etc.) (1,2)

GG. ALTERNATING CURRENT FUNDAMENTALS

1. Describe and state the pros and cons of single phase current vs. three phase current. (1,2)

2. Demonstrate and discuss the various characteristics of AC sine waves (frequency, period, negative and positive amplitude, RMS value), impedance, resistances. (1,2)

3. Apply resistance sine waves to the various phase relationships. (1,2)

HH. ELECTRIC MOTORS

1. Describe magnetism and its relationship to electric motors.

a. Explain electromagnets and polarity in relation to current flow. (1,2)

b. Explain how an electromagnet supplies the magnetic field for motor rotation. (1,2)

2. Demonstrate magnets in an induction type motor (stators and rotors). (1,2)

3. Demonstrate the safety rules in working with electric motors. (1,2)

4. Identify and discuss common types of motor mounts (cradle mount, blower frame mount, three ring mount, lug ring mount, rigid mount, pump mount). (1,2)

5. Describe the advantages and disadvantages of various motor enclosures (open, open-drip proof, totally enclosed, explosion proof, submersible). (1,2)

6. Identify and discuss the purpose of the major parts of an open drive motor (stator assembly, rotor, end bells, overload, centrifugal control, starting switch, assembly bolts). (1,2)

7. Demonstrate the types of single phase motors and state the major use of each type (split phase, shaded pole, capacitor start induction run C.S.I.R., capacitor start capacitor run C.S.R., permanent split capacitor P.S.C.) (1,2)

8. Define the purpose, construction and advantages of a three phase motor. (1,2)

9. Describe the purpose and use of information given on the motor data plate. (1,2)

10. Split phase motors.

    a. Demonstrate the common applications of split phase motors and the common horse power range of these motors (fans, oil burners, pumps, blowers, domestic refrigeration compressors, 1/20-3/4 HP, open drive and hermetic). (1)

    b. Define the two types of windings on a split phase motor and the characteristics of these windings (start, run). (1)

    c. Describe the components of a split phase motor and review the purpose of these components. (1)

    d. Define the NEMA motor lead codes for start and run windings and the typical motor lead color codes. (1)

e. Describe motor wiring for the directions of rotation of a split phase motor. (1)

f. Wire a split phase dual voltage motor to a 208/240 VAC supply. (1,2)

g. Disassemble, inspect, clean, and reassemble a split phase motor. (1)

11. Shaded pole motors

a. Describe the common applications of shaded pole motors (refrigerator evaporator fans, refrigerator condenser fans, window air conditioner fans, furnace flowers, furnace combusion fans, timers). (1,2)

b. Describe the construction of the shaded pole stator. (1)

c. Define the disadvantages of using shaded pole motors and the most common remedy for motor failure. (1)

d. Demonstrate the relationship of the number of poles to the motor RPM in shaded pole motors. (1)

e. Define the voltages of shaded pole motors. (1)

f. Describe the mechanical and electrical methods of reversing the rotation of shaded pole motors. (1,2)

g. Demonstrate the methods of varying the speed of shaded pole motors. (1,2)

h. Perform a maintenance check on a shaded pole motor. (1)

12. Capacitor motors

a. Describe the characteristics and common applications of capacitor motors. (1,2)

b. Define the two types of capacitor motors (open drive, hermetic). (1)

c. Define the advantages of the C.S.I.R. motor. (1)

d. Define the advantages of the C.S.R. motor. (1)

e. Define the advantages of the P.S.C. motor. (1)

f. Demonstrate the wiring diagrams of the capacitor motors. (1)

13. Three phase motors

a. Define the difference and major advantages and disadvantages of the major types of three phase motors (synchronous, squirrel cagerotor, and wound rotor). (1)

b. Describe the electrical characteristics of three phase motors and their components. (1)

c. Define the differences between a delta wound motor and wye wound motor.

d. Reverse the rotation of a three phase motor. (1,2)

14. Describe common motor problems, the causes of the problems, and the remedy to solve the problems.

a. Excessive noise. (1)

b. Failure to start. (1)

c. Overheating of motor. (1)

d. Overheating of bearings. (1)

e. Rotor of stator burned out. (1)

15. Demonstrate the types of motor V-pulleys (sheaves) and the methods for determining the size of the pulleys (standard, step, adjustable). (1,2)

16. Calculate the size belt needed to attach to two pulleys given the diameter of the pulleys and the distance the pulleys are apart OC. (1,2)

II. ELECTRICAL CIRCUITS AND WIRING DIAGRAMS.

1. Define various symbols used to graphically represent various electrical components and devices. (1,2)

2. Define the three basic areas all circuits have in common (source of power, conductor, and load). (1,2)

3. Define the other two devices most circuits contain (circuit protective devices and circuit controlling devices.) (1,2)

4. Circuit protective devices.

   a. Identify common types of overcurrent protective devices, explain their operation, and discuss the pros and cons of various applications (blade type cartridge fuse, ferrule type cartridge fuse, type S plug fuse, edison base plug fuse, circuit breaker, fusible link). (1,2)

   b. Define the operation of a single element fuse. (1,2)

   c. Define the operation of a time delay fuse. (1,2)

   d. Define the operation of a circuit breaker. (1,2)

   e. Define the national electric code requirements for fuses less than 600 volts. (1,2)

   f. Define the national electric code requirements for circuit breakers that are less than 600 volts. (1,2)

   g. Define pressure activated protection devices. (1,2)

   h. Demonstrate the function and types of electrical system protection devices (bimetal overload, magnetic overload, thermal overload relay, lockout relay, solid state compressor motor protector). (1,2)

   i. Install a lockout relay. (1,2)

   j. Examine and test a solid state compressor motor protector. (1,2)

5. Define the components and operation of the major circuit controlling devices - switches (3 and 4 way, rotary single, multiple position, push button-PBNO-PBNC, thermal types, pressure types, SPST, SPDT, DPST, DPDT, limit types, magnetic, photoelectric, proximity, etc.)

6. Define the basic design, electrical rules, and purpose of series circuits. (1,2)

7. Define the basic design, electrical rules, and purpose of parallel circuits. (1,2)

8. Define the basic design, electrical rules, and purpose of parallel circuits. (1,2)

9. Compute series, parallel, and series parallel circuit electrical values. (1,2)

10. Demonstrate pictorial and ladder schematic wiring diagrams and list the major characteristics of each type. (1,2)

11. Define the common faults of electrical circuits (open circuits, closed circuits, and short circuits.) (1,2)

12. Demonstrate the major steps in building and tracing a ladder schematic and trace the electrical current through several ladder schematics. (1)

13. Demonstrate the ability to draw various pictorial and schematic wiring diagrams and ladder diagrams. (1)

JJ. OTHER ELECTRICAL CONTROLS AND COMPONENTS

1. Demonstrate a working knowledge of the gas heating system. Define the safeties and controls involved in the system. Describe all tools and procedures used in proper diagnosing and repairing of the system.

   a. Types and history of gas combustion. (1,2)

   b. Types of gas fired furnaces and burners--location of parts. (1,2)

   c. Safeties used in residential gas fired equipment. (1,2)

   d. Control systems used in residential gas fired equipment. (1,2)

   e. Setting BTU input. (1,2)

   f. Annual service. (1,2,3,4)

   g. Problem diagnosis - electrical. (1)

   h. Problem diagnosis - mechanical. (1)

   i. Safeties in commercial burners. (1,2)

   j. Problem diagnosis - commercial. (1)

2. Describe the components, construction. wiring specifications and purpose of step up and step down transformers. (1)

3. Identify the three types of termostats and their components and explain the pros and cons of each type (low voltage thermostats, milivolt thermostats, line voltage thermostats, aquastats, PTC's). (1,2)

   a. Describe the operation of a bimetal temperature sensing element, the various shapes of the bimetals, the function in opening and closing contacts (helix, cantilever, "U", spiral, snap disc). (1)

   b. Describe the difference between a snap action and mercury bulf thermostat contact, the function of each and the pros and cons of using these contacts. (1)

   c. Describe thermostat heat anticipators. (')

   d. Describe the operation and advantages of a time controlled thermostat. (1,2,3)

   e. Determine heat anticipation of a thermostate and properly adjust the heat anticipator. (1,2)

   f. Demonstrate the digital stats and multi set back theory. (1)

   g. Install a wall thermostat. (1,2)

4. Demonstrate and discuss the functions and specifications of different types of relays and their parts.

   a. Demonstrate and explain the purpose and function of a contacter relay. (1,2)

   b. Demonstrate and discuss various motor starting relays (potential, coil type and hot wire type current relays, solid state relays). (1)

   c. Describe selection specifications of motor relays. (1)

   d. Demonstrate and explain the purpose of time delay relays. (1)

   e. Draw connecting wiring to various types of relays and a contactor. (1)

   f. Wire a hot wire and coil type current relay. (1)

g. Wire a potential relay. (1)

h. Wire a fan relay. (1)

i. Check wiring and various relays with electrical test instruments (ohmeter, voltmeter, ammeter). (1,2)

5. Demonstrate understanding of the electromagnetic operation of a solenoid valve and the two types of solenoids (push type, pull type). (1,2)

6. Demonstrate and discuss the types of capacitors and the role of capacitors in the operation of motors (run capacitor and start capacitor). (1,2)

a. Describe use of solt start components vs. hard start. (1,2)

b. Determine the sizes of various capacitors. (1)

c. Calculate the capacitance of capacitor wired in series and parallel. (1)

d. Define the factors to consider when replacing capacitors. (1)

e. Define the major causes of capacitor failure (discuss type of oil used in run capacitor). (1)

f. Wire a run capacitor with a P.S.C. compressor motor. (1,2)

g. Wire a run capacitor with a C.S.R. compressor motor. (1,2)

KK. OIL HEATING

1. Demonstrate a thorough understanding of the oil heating system. Describe all the controls and safeties in detail. Define proper procedures used in diagnosing and correcting the service problems.

a. Types of burners. (1,2)

b. Determining B.P.H. rate - nozzles. (1,2)

c. Automatic oil burner controls. (1,2)

d. Oil burner wiring. (1,2)

e. Servicing primary and CAB cell controls. (1)

f. Annual service required. (1,2,3,4)

g. Adjusting combusion efficiency. (1,2)

h. Ignition and pump problems. (1,2)

i. Basic burner service methods. (1,2)

j. Combustion problems - pulsations. (1,2)

LL. ELECTRICAL TEST METERS

1. Demonstrate the safety precautions when taking various electrical measurements. (1,2)

2. Demonstrate the proper procedure when probling circuits to take test readings. (1,2)

3. Demonstrate the ability to read dial type meters including digitals. (1,2)

4. Demonstrate the ability to take electrical measurements with volt meters, amp probes, ohm meters, watt meters, and VOM's. (1,2)

MM. ELECTRIC HEATING

1. Demonstrate a working knowledge of the operation and service involved in the electric heating system.

a. Describe different types of electric heating with emphasis on efficiency. (1,2,3)

b. Describe theory of operation of electric furnaces. (1,2)

c. Demonstrate installation and servicing problems encountered with electric furnaces. (1,2)

d. Define heat pumps, their advantages, disadvantages and operating characteristics. (1,2,3)

e. Define reversing valves and defrost mechanisms used in heat pumps. (1,2)

f. Describe trouble shooting heat pumps and related control systems. (1,2)

g. Describe electric boilers, their advantages and limitations. (1,2)

h. Demonstrate analysis of electric hydronic systems and accessories. (1)

i. Define troubleshooting electric hydronic controls and contol systems. (1)

j. Defin problems encountered with radiant panel electric heating and line voltage thermostats. (1)

NN. HEAT PUMPS

1. Demonstrate installation of both air to air heat pumps and air to water heat pumps.

a. Read prints, diagrams, and manufacturers installation specifications. (1,2)

b. Mount packaged and split systems based on space requirements, mounting methods, and adequate supply of water, the specified air flow, ventilation, accessability, drain facilities, duct layout, piping layout, installation codes. (1,2)

c. Connect electric motors, heating coils and controls based upon electrical codes and power, voltage and phase requirements. (1,2)

d. Make the pipe connections including couplings and fittings to the following: Line, water, refrigerant, drain and defrost. (1,2)

e. Perform the necessary mechanical and electrical checks, tests, and measurements. (1,2)

f. Purge, charge and test the system. (1,2)

g. Start up and test the completed system and adjust for efficiency. (1,2)

OO. HYDRONIC HEATING AND COOLING

1. Describe proper sizing of hydronic heating system - selection of baseboard pumps and proper controls. Describe the proper information to install and service hydronic heating systems.

a. Define theory of calculating heat gains. (1,2)

b. Calculation of heat gain on project house. (1,2)

c. Describe boilers, boiler ratings, sizing and piping arrangements. (1,2)

d. Define ratings of heat distributing units, location and sizing procedures. (1,2)

e. Demonstrate air cushion tanks and air elimination devices. (1,2)

f. Demonstrate piping layouts and practices. (1,2)

g. Develop design water temperatures and pumps. (1,2)

h. Define zoning methods and pipe sizing. (1,2)

i. Demonstrate design of complete system for project house. (1,2)

j. Describe residential steam heating systems. (1,2)

PP. DUCT DESIGN

1. Demonstrate design of ductwork used in air conditioning systems. Describe heat loss, duct sizing and register location and air circulation.

a. Demonstrate typical building construction and blueprints. (1,2)

b. Define comfort, how the human body loses heat, importance of good design of heating and air conditioning systems, basics of heat flow through building walls, windows, ceilings, and floors. (1,2,3)

c. Describe infiltration and how to calculate it. (1,2)

d. Work heat loss calculation work sheet, solar, latent, and internal heat gains preparing for cooling load calculation procedure. (1,2)

e. Comparative fuel costs and good venting methods. (1,2)

f. Describe history of warm air heating, 40 years of industry-sponsored research investigations at University of Illinois leading to development of design procedures. (1,2)

g. Demonstrate air flow patterns in ducts and measurement of pressures and resistances to air flow. (1,2)

h. Describe types of fans and fan performance. Demonstrate equal friction method of duct sizing. (1,2)

i. Demonstrate the selection of good fittings; methods of installation; principles of continuous air circulation. (1,2)

QQ. AIR DISTRIBUTION

1. Describe various problems that can arise from a system that is not properly balanced. Demonstrate various methods of air balancing.

a. Define basic concepts fluids vs pressure (air). (1,2)

b. Demonstrate measurement of pressure instruments and their use in balancing. (1)

c. Describe air flow through ducts. Velocity changes due to design. (1)

d. Define horsepower vs. C.F.M (1)

e. Define laws governing fans. (1)

f. Demonstrate selecting the proper fan for the job. (1)

g. Describe balancing the proper relationship between fan and duct size. (1)

h. Define cost saving with proper balancing. (1)

i. Demonstrate adjustments made during balancing. (1)

RR. BASIC REFRIGERATION KNOWLEDBE NEEDED

1. Describe the terms used in Air Conditioning and Refrigeration industry. Define pressure and temperature as it pertains to boiling liquids. Describe air treatment needed for various comfort conditions. Psychometrics.

a. Describe the basic parts in the refrigeration cycle. (1,2)

b. Describe basic terminology used in refrigeration. (1,2)

c. Define temperature, latent heat and pressure. (1)

d. Define enthalpy and its use, heat transfer. (1)

e. Demonstrate steam tables. (1)

f. Describe body comfort. (1)

g. Demonstrate body comfort - psychometrics. (1)

h. Describe psychometrics. (1)

i. Demonstrate psychometrics and basic load estimation. (1)

j. Describe load estimation. (1)

2. Demonstrate a working knowledge of the reciprocating compressor and all other components involved in the refrigeration system. Define each of the four major components involved in the system and how they affeet the overall efficiency of the system.

a. Demonstrate mechanical refrigeration cycle. (1)

b. Define properties of refrigerant. (1)

c. Describe gas laws. (1)

d. Define pressure - enthalpy relationships. (1)

e. Describe unit capacity and refrigeration effect. (1)

f. Define efficiencies of the compressor. (1)

g. Demonstrate effect of subcooling and superheating refrigerants. (1)

h. Define power requirements of compressors. (1)

i. Describe lubrication and valves. (1)

j. Demonstrate compressor unloaders. (1)

k. Demonstrate metering devices. (1)

l. Demonstrate proper line sizing techniques (1)

m. Demonstrate general problem solving techniques. (1)

3. Describe various types of systems used in residential and commercial air conditioning and refrigeration. Define air distribution fan theory and total comfort. (Human or product).

a. Describe centifugal refrigeration system. (1)

b. Describe control of centrifugal. (1)

c. Describe capacity control methods. (1)

d. Describe absorption system. (1)

e. Describe heat pump - systems. (1)

f. Define source of heat. (1)

g. Demonstrate use of solar energy. (1)

h. Describe air wash units. (1)

i. Describe fan theory. (1)

j. Define air pressure in ducts. (1)

k. Demonstrate fan efficiency and design.

SS. AIR CONDITIONING AND REFRIGERATION - ELECTRICAL

1. Describe application of basic electricity as it applies to the servicing and installation of heating, air conditioning and refrigeration equipment.

a. Demonstrate understanding of electron theory, DC current flow, conductors and insulators, voltage and resistance. (1,2)

b. Demonstrate Ohms Law, resistance in series and parellel circuits and power. (1,2)

c. Demonstrate magnetism, magnetic fields, generator principles, transformers, switches and relays. (1,2)

d. Define inductance, impedance and capacitance. (1,2)

e. Describe electric motors. (1,2)

f. Demonstrate measuring instruments, schematic symbols and circuits. (1,2)

g. Define temperature and pressure sensing controls. (1,2)

h. Define fundamental heating control circuits. (1,2)

i. Define fundamental cooling control circuits. (1,2)

j. Define fundamental refrigeration control circuits. (1,2)

2. Basic Control Systems - Demonstrate principles of electric controls used in air conditioning and refrigeration. Demonstrate motor starting and safety contols. Demonstrate installation and service techniques.

   a. Define domestic refrigeration principles of control and sequence of operation. (1,2)

   b. Describe refrigeration motor controls, thermostats, pressure switches and timers. (1,2)

   c. Demonstrate motor starting techniques; hot wire relays, current relays, potential relays and centrifugal switches. (1,2)

   d. Describe defrost controls used in domestic refrigeration. (1,2)

   e. Describe domestic ice maker circuits and controls. (1,2)

   f. Describe commercial systems control principles and sequence of operation. (1,2)

   g. Describe commercial compressor motor starting systems, both single and three phase. (1,2)

   h. Describe humidification and dehumidification controls. (1,2)

   i. Describe window air conditioning system controls; thermostats, overloads and motor starting controls. (1,2)

   j. Describe window heat pump controls and sequence of operation. (1,2)

3. Advanced electrical control systems. Demonstrate proper selection of controls and their placement in the electrical circuit.

   a. Describe thermostats: theory of operation, circuitry, installation, calibration and trouble shooting. (1,2)

   b. Describe transformers: sizing, wiring and troubleshooting. (1)

   c. Describe contactors, motor starters and overload protection, theory of operation, application and troubleshooting. (1)

d. Demonstrate evaporator blower controls, single and multiple speed, problems encountered in relation to accessories. (1)

e. Demonstrate heat pump reversing valves and liquid solenoid valves, theory of operation and troubleshooting. (1)

f. Demonstrate pressure switches, defrost solenoids and timers. (1)

g. Define methods of low ambient control. (1)

h. Demonstrate by combining above controls into systems. (1)

4. Advanced control systems. Demonstrate working knowledge of electrical and pneumatic control systems used in commercial building.

a. Describe modulating control circuit application. (1)

b. Describe modulating control circuit operation. (1)

c. Demonstrate modulating controllers: room thermostats, remote bulf temperature controllers and pressure controllers. (1)

d. Demonstrate modulating motors: reversible capacitor motor, balancing relay, feedback potentiometer and gear train. (1)

e. Demonstrate installation and troubleshooting procedures. (1)

f. Demonstrate valves, dampers and linkages, installation and adjustment. (1)

g. Describe pneumatic control systems; system operation, measured variable, controlled variable, control agent and controlled devices. (1)

h. Describe controllers; controller feedback, measuring element, supply pressure. (1)

i. Describe control modes; two-position, proportional and proportional plus reset. (1)

j. Demonstrate applications of pneumatic controls. (1)

TT. AIR CONDITIONING AND REFRIGERATION SERVICE PROCEDURES

1. Demonstrate techniques required in the use of instruments, meters, gauges, and soldering equipment used in the installation and service of various systems.

   a. Demonstrate soldering equipment uses. (1,2)

   b. Demonstrate soldering procedures. (1,2)

   c. Demonstrate types of solder used. (1,2)

   d. Demonstrate pressures - absolute and atmospheric - gauges. (1,2)

   e. Demonstrate evacuation of the refrigeration system. (1,2)

   f. Demonstrate charging of the refrigeration system. (1,2)

   g. Demonstrate electrical meter use. (1,2)

   h. Demonstrate checking electrical circuits. (1,2)

   i. Demonstrate leak testing the refrigeration system. (1,2)

   j. Demonstrate adding refrigerant charges. (1,2)

2. Describe basic problems that arise in residential air conditioning systems. Demonstrate the proper use of meter and gauges used in diagnosing these problems and the procedures used in correcting them.

   a. Describe compressor function and problems arising with it. Valves and lubrication. (1)

   b. Describe coil evap. and cond. coils problems and functions. Use of gauges and charging of equipment. (1)

   c. Describe metering devices. (1)

   d. Demonstrate PH charts. Plot heating condition. (1)

   e. Describe commercial walk in. Pressure control. Settings for freezer and refrigeration. (1)

   f. Describe domestic refrigerators and window shakers - how they differ from domestic central units. (1)

3. Demonstrate a working knowledge of commercial refrigeration both from

an installation and service standpoint. Describe walk in freezers, reach in freezers and store coolers--also types of temperature control and methods of defrosting.

a. Describe types and uses of commercial equipment. (1,2)

b. Demonstrate load calculations and equipment selection of commercial comfort equipment. (1)

c. Demonstrate control devices used in commercial equipment. (1)

d. Describe selection of proper system to meet the needs of the commercial job (human comfort). (1)

e. Describe freezer construction and design. (1)

f. Demonstrate sizing a freezer for a given application. (1)

g. Demonstrate proper component selection for freezer application. (1)

h. Describe electrical controls used in commercial applications (product).

UU. CONSTRUCTION TRADES

1. Demonstrate the proper use and selection of carpentry and building trade hand and power tools. (1,2)

2. Demonstrate knowledge of properties, handling procedures, and fabrication techniques of common building materials (wood, concrete, metals, insulation). (1,2)

3. Demonstrate an understanding and comprehension of various local, state and national building codes for the following areas: structural codes, electrical codes, fluid component codes, insulation codes, heat exchanger codes, and residential energy codes. (1,2)

4. Describe the purpose, functions and construction methods involved in building residential and commercial buildings.

a. Describe the materials and construction techniques in foundations. (1,2)

b. Describe the materials and construction techniques of walls. (1,2)

c. Describe the materials, styles, and construction techniques of residential and commercial roofs. (1,2)

UNIT QUIZ & EXAMS

Quiz, unit 2, INTRODUCTION TO ACTIVE SOLAR

Quiz, unit 3, THE SUN

Examination, units 1/2/3, INTRODUCTORY & THEORY

Quiz, unit 4, SOLAR SYSTEM DESIGN ENGINEERING

Quiz, unit 5, THE SOLAR SYSTEM

Examination, unit 4/5, ENGINEERING

Quiz, unit 6, THE COLLECTOR

Quiz, unit 7, STORAGE

Quiz, unit 8, ELECTRICAL SYSTEM

Examination, units 6/7/8, DESIGN

Quiz, unit 9, WHOLE HOUSE

Quiz, unit 10, SOLAR APPLICATION

Quiz, unit 11, SERVICING SOLAR INSTALLATIONS

Examination, units 9/10/11. INSTALLATION & MAINTENANCE

Unit 2 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. A solar heating and/or cooling system is any system which utilizes solar energy as source of heat.

T F 2. A passive system usually has no moving parts and is not the major concern of the people taking this course.

T F 3. A concentrating solar collector best utilizes diffuse solar radiation.

T F 4. The insulation beneath the absorber plate helps produce a quieter operating solar collector.

T F 5. Like flat plate collectors, concentrating collectors can operate in any weather conditions so long as minimal light conditions exist.

T F 6. An R-10 insulation rating is more than adequate for the surfaces of liquid thermal storage units.

T F 7. Packing and/or side wall stress is not a problem in a pebble-bed heat storage solar system.

T F 8. Insulation material on the bottom of a 6' water storage tank must withstand a compression weight of 280 pounds per square foot.

T F 9. A good quality steel tank will not be subject to any problems during the life of the system.

T F 10. While a solar air system requires lower capital costs, more electric energy is required during its life to move the heat from the collector to storage to use as compared to a liquid solar system.

T F 11. Liquid solar systems have a long history of working well and the critical cost is low.

T F 12. A heat pump could be considered as an auxilliary heat supply in some areas of the country.

T F 13. Of the absorption refrigeration currently in use, the Lithium-Bromide chillers appear to hold the most promise.

T F 14. Through the use of a Solar Rankine-Cycle Engine, a device such as a heat pump could become a solar related device even in its cooling cycle.

T F 15. The cost of conventional energy (gas, oil, etc.) should level off within the next five years.

T F 16. The amount of solar radiation available during the heating season is a major economic consideration for a solar heating system.

T F 17. Currently, electricity is the best fuel to buy in terms of cost per million BTU's throughout the country.

T F 18. Property taxation rate and loan interest rate are just two of the items which must be considered when costing a solar heating system.

T F 19. Except for minor differences, cities along the same latitude have equal solar BTU's available to them.

T F 20. Snow is not as much of a consideration when planning a solar energy system for Flagstaff, Arizona as for Boston, Massachusetts.

Fill in the blanks with the word (or words) which most accurately completes the thought.

21. The two basic types of solar energy systems are called active and _____.

22. A roof monitor, a south-facing window, and a _____ are all examples of passive solar collectors.

23. The two basic types of solar collectors are _____ or _____.

24. The absorber plate is usually _____ in color which aids in _____ the solar radiation.

25. Solar collectors tend to lose heat through _____, _____ and/or _____.

26. The layer of still air between the glass and the absorber acts to reduce _____ loss.

27. Because of their size, air thermal storage units are normally placed into the building _____ constructing.

28. Round pebbles _____ to _____ in size are ideal for a pebble-bed heat storage unit.

29. If a horizontal pebble-bed heat storage unit is used, the height of the unit must not exceed _____.

30. Water heat storage units are subject to_____, especially at the _____ _____.

31. Two types of auxilliary electric heat in solar heating systems are _____or_____or both.

32. For cooling residential building, solar energy is only directly useful in_____methods.

33. In terms of realistic economics, only the _____ system appears to be practical for solar cooling, at least into the early 1980's.

34. A heat pump is a mechanical vapor-compression system consisting of a _____, _____, _____ _____ and an_____.

35. A prototype solar heating system, using circulating air, has been operational since 1957 with _____major problems and essentially no _____costs.

36. Solar heating should provide_____percent of the annual heating requirements to be practical and economical.

37. Considerations that may influence users toward solar heating are:
    1. Incorporation of systems into_____ _____.
    2. First costs verses _____ _____ _____
    3. Ease of _____and_____
    4. _____and reliability.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

Which item is NOT a component of an all-air solar heating/solar cooling system?
a. auxiliary furnace
b. heating/cooling distribution system
c. solar collector
d. boiler
e. cooling unit
f. thermal storage unit

39. Of the cooling systems listed below, indicate which is currently available for residential solar cooling.
    a. evaporative cooling through rock bed
    b. Munter's environmental control
    c. Thiethylene glycol open cycle diseccant system
    d. radiative cooling

40. Based on the factors presented in this unit, it is essential that solar heating/solar cooling systems provide the user with:
    a. comfort and safety
    b. maximum return for dollar invested
    c. a good looking exterior to the building
    d. snob appeal

T F 41. There is attention given to the health and safety of people related to solar heating utilization.

T F 42. A solar home owner can do nothing if a neighbor's tree grows and shades the collector.

T F 43. It is extremely difficult to find consistent building codes for solar heated buildings.

T F 44. The Uniform Solar Energy Code has been found unacceptable for solar heating standards and guidelines.

T F 45. Cross connection refers to hooking potable water with sewer connections.

T F 46. Due to the lack of local codes, inspectors show little concern for solar heating equipment.

T F 47. Changing components may be simpler than changing codes if controversy arises.

T F 48. Because of the urgency to experiment with solar heating, there aren't any jurisdictional labor problems.

T F 49. A solar heating system may be considered a liability by some appraisal practices.

T F 50. Insurance companies are very reluctant to underwrite solar heated buildings.

T F 51. The Federal Trade Commission is the agency that regulates warranties.

T F 52. A full warranty may only relate to a part of a product.

T F 53. A full warranty states that there cannot be a time limit to the duration of the guarantee.

T F 54. Pro-rating is generally associated with limited warranties.

T F 55. A limited warranty protects only the original purchaser.

T F 56. Implied warranties are explicit in identifying the function of a product.

T F 57. Warranties are to be prominently displayed on the product or packaging.

58. Several aspects of health and safety in owning solar heating equipment relate to _____ and _____problems.

59. Problems of "Right to Light" arises from _____and _____shading.

60. If a collector creates glare, the property owner may be required to _____ _____ _____.

61. Proper placement and purpose for building on a lot in a given location is related to_____.

62. Incentives to install a solar system may be encouraged by legislation could be considered _____or_____

63. Compensatory regulations would deal with _____and_____ such as _____, _____ and _____

64. Warranties are classified as either _____, _____, or _____

65. Problems with building codes relate to the:

a._____

b._____

c._____

d._____

66. When dealing with solar heating systems, an appraiser may choose to:

a._____

b._____

c._____

67. Regulatory legislation includes:

a. _____

b. _____

c. _____

d. _____

68. A full warranty must include:
    a. repairs at no cost and done in reasonable time
    b. cover only original purchase
    c. if not repairable replace or refund money
    d. all of the above

69. Which of the following considerations must be dealt with when determining placement of solar collectors.
    a. freedom from glare
    b. right to light
    c. building codes
    d. all of the above
    e. none of the above

Unit 3 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The sun's energy can be converted from electromagnetic waves to heat.

T F 2. The sun is approximately 93 million miles from earth.

T F 3. The earth's inhabitants are not all that interested in solar energy.

T F 4. Infrared radiation waves are long.

T F 5. The sun produces the greatest amount of energy in the visible range.

T F 6. A solar collector absorbs radiation from two of the three radiation regions of interest to this course.

T F 7. The upper atmosphere, clouds and dust all contribute to scattering solar radiation.

T F 8. Solar energy on a horizontal surface will show month to month variations.

T F 9. Solar rays must pass through a larger thickness of atmosphere in the early morning.

T F 10. The exposure of solar energy on vertical surfaces is the same as the exposure on horizontal surfaces.

T F 11. Of greatest use is knowing the expected monthly radiation on a surface during the period of the heating season.

Fill in the blanks with the word (or words) which most accurately completes the thought.

12. It is to the sunlight that was received in past ages that we owe the existence of our _____ fuels.

13. The three types of solar rays which are of interest to this course are _____, _____ and _____

14. The abbreviation of British Thermal Units per square foot is _____.

15. To convert Langleys into BTU/ft^2, multiply by _____

16. UV is the abbreviation for _____

17. Infrared is abbreviated_____

18. Materials with a temperature below 800°F emit only_____ radiation.

19. In the winter, the sun is_____in the sky than in the summer, and the resultant angle_____the amount of radiation intercepted on a flat surface.

20. The amount of energy intercepted by a horizontal surface is much _____as the angle (height) of the sun increases.

21. Generally speaking, the angle of the sun above the horizon at noon is about_____in the winter and _____in the summer for latitudes near 40°N.

22. The greatest intensity of solar radiation occurs during the_____ hours.

23. North wall exposure to direct solar radiation is not important to people living in the_____hemisphere.

24. In the northern hemisphere, the solar collector is aimed_____

25. As a general rule, a solar collector used for heating only should have a tilt equal to the _____plus_____degrees.

26. A solar collector can be oriented _____east or west of due south without any serious effect on its collecting ability.

27. A solar collector oriented 15 degrees to the east of due south will _____the time of peak collection by_____hour.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

28. The earth offers the sun what quality of target to absorb its radiation?
    a. very good
    b. average
    c. very small
    d. none of the above

29. If the amount of solar radiation received by the earth were reduced,
    a. nothing would happen
    b. the earth would freeze
    c. the earth would boil

30. The surface temperature of the sun is approximately
    a. 5,000°F.
    b. 10,000°F.
    c. 15,000°F.
    d. 20,000°F.

31. Langley/min is the abbreviation for
    a. calories per square centimeter
    b. the 47 second minute named after Carl Langley
    c. calories per square centimeter per minute
    d. both A and C

32. The solar constant is equal to
    a. 1.940 Langley's/min.
    b. 428.7 BTU/(ft.^{2}h)
    c. both A and B
    d. none of the above

33. When someone says than an air conditioner is rated at one ton, they mean
    a. the unit will produce the same BTU's of cooling as melting one ton of ice in one day
    b. the air conditioner weighs one ton
    c. the unit will cool one ton of anything for a day

34. To tilt the solar collector so that it is perpendicular to the sun's rays is
    a. advantageous
    b. expensive
    c. a waste of time
    d. all of the above

Unit 1, 2 and 3 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The two basic types of solar energy systems are called active and passive.

T F 2. The two basic types of solar collectors heat metal or liquid.

T F 3. The absorber plate is usually silver in color which aids in reflecting the difuse solar radiation.

T F 4. Solar collectors tend to lose heat through leaks, a high R factor, and convection.

T F 5. Because of their size, air thermal storage units are normally placed into the building after construction.

T F 6. For cooling residential buildings, solar energy is only directly useful in cooling methods using refrigeration cycles.

T F 7. A prototype solar heating system, using circulating air, has been operated since 1937 with no major problems and essentially no maintenance costs.

T F 8. Solar heating should provide 50-80 percent of the annual heating requirements to the practical and economical.

T F 9. It is to the sunlight (solar energy) that was received in the past ages that we owe the existence of our atomic fuels.

T F 10. To convert Langleys into BTU/ft^2, multiply by 221.

T F 11. Materials with a temperature below $800^{o}F$ emit only infrared radiation.

T F 12. Radiation is termed direct radiation if it has not been scattered by clouds and dust and diffuse if it has.

T F 13. The sun's position in our sky varies because, as the earth follows its orbit, the tilt of the earth's axis changes our relationship with the sun.

T F 14. The greatest intensity of solar radiation occurs during the early morning hours when the air is cleaner.

T F 15. As a general rule, a solar collector used for heating only should have a tilt equal to fiteen degrees plus latitude.

T F 16. The optimum tilt of a collector occurs when the angle of the collector is always the same as the incoming radiation.

Fill in the blank(s) with the word (or words) which most accurately completes the thought.

17. A passive system usually has _____moving parts and is not the _____of the people taking this course.

18. A concentrating solar collector best utilizes _____ solar radiation.

19. A chief disadvantage to the use of concentrating collectors involve the expense necessary to _____on the _____ throughout the day.

20. While a solar air system requires _____capital costs, _____energy is required during its life to move the _____ from the collector to storage for use than for a liquid system.

21. Which gives off the greatest quantity of heat: A-a gallon of water cooled from 210^{o} to 188^{o}F, or B-a gallon of water cooled from 48^{o} to 18^{o}F?_____

22. Of the absorption refrigeration currently in use, the _____ _____chillers appear to hold the most promise.

23. Through the use of a solar _____-_____engine, a device such as a heat pump could become a solar related device in both cooling and heating modes.

24. It is essential that the solar heating/solar cooling system provide the maximum possible return for the dollar invested based on savings over the _____, _____, and _____ of conventional heating systems.

25. Boston, Massachusetts receives 5"_____precipitation per year than Seattle, Washington.

26. The storage of inexpensive_____fuels make it imperative to design efficient solar heating systems.

27. Beside radiant (solar) energy, three other forms of energy useful to people are:_____,_____and_____

28. The electromagnetic spectrum of the sun's rays depicts_____ different types of radiation, but in this course only_____ _____ and_____are of interest.

29. The instrument used to measure solar energy is called a_____

30. British Thermal Units per square foot is expressed in abbreviated for as_____

31. To convert Langleys into British Thermal Units per square foot, multiply Langleys by_____

32. UV means_____and is_____wave length radiation.

33. With the outer space value of solar energy equalling 100 percent, _____percent is the normal maximum reaching the earth.

34. The cooling capacity of one ton of ice is_____BTU/h.

35. _____energy would be intercepted if the collector were to track the sun across the sky.

36. The generally accepted tilt of a heating only collector is latitude plus _____degrees.

37. Maximum solar intensity occurs at noon when the sun is due_____ in this hemisphere.

38. Atmosphere, vegetation, and physical barriers cause the potentially useful solar energy to_____from location to location, month to month, day to day, and hour to hour.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

39. The surface temperature of the sun is approximately:
    a. 5,000°F.
    b. 10,000°F.
    c. 15,000°F.
    d. 30,000°F.

40. Langley/min is the abbreviation for
    a. calories per square centimeter
    b. calories per square centimeter per minute
    c. calories per cubic centimeter per Langley minute

41. The solar constant is equal to
    a. 1.940 Langley's/min.
    b. 428.7 BTU/(ft.²h).
    c. all of the above
    d. none of the above

42. Which item is not a component of an all-air solar heating/solar cooling system?
    a. auxiliary furnace
    b. heating/cooling distribution system
    c. solar collector
    d. boiler
    e. cooling unit
    f. thermal storage unit

43. Based on the factors presented in this unit, it is essential that solar heating/solar cooling systems provide the user with
    a. comfort and safety
    b. maximum return for dollar invested
    c. a good looking unit
    d. snob appeal

Unit 4 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. When heating directly from the collectors of an all air system, the heated air normally passes through the storage unit before entering the space to be heated.

T F 2. Heating domestic water is possible by adding a fin tube heat exchanger in the air stream leaving the collector.

T F 3. A T/P valve is installed at the pre-heated domestic water tank to prevent overheating of this water.

T F 4. Ducts with insulation value of R-4 should be installed to reduce heat loss in an all air system.

T F 5. A bypass duct is always required in an all-air solar system.

T F 6. When storing heat with a hydronic solar heating system the storage pump is off.

T F 7. When heat is being stored in a closed loop hydronic solar heating system the collector fluid flows directly to the storage unit.

T F 8. The purpose of the purge cycle is to drain the fluid from the collector.

T F 9. The simplest installation of a heat pump in a solar heating system is to use the heat pump as an auxiliary heat source.

T F 10. A heat pump can be installed so it will draw heat from the solar storage unit.

T F 11. The collector pump will short-cycle if the "on" and "off" points on the differential thermostat are too close.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

12. One way to prevent scalding water from entering the domestic hot water line is to install a
    a. pressure/temperature relief valve
    b. drop line
    c. thermostatic mixing valve
    d. air cushion tank

13. A well designed all air solar system will have a pressure drop of approximately 0.3 inches of water in the
    a. collector
    b. storage unit
    c. duct system
    d. both A and B are correct

14. The collector loop of a hydronic solar system contains
    a. collector
    b. heat exchanger
    c. pump
    d. all of the above

15. If a heat pump is used for auxiliary heat, the "solar" water coil is installed upstream from the refrigerant coil to
    a. avoid higher head pressures on the compressor
    b. make installation easier
    c. to increase the heat output from the heat pump
    d. all of the above are correct

In the following completion questions place the correct number, word or phrase in the blank(s) provided with each question.

16. List the five basic modes of operation possible with all air solar systems:

    a. _____

    b. _____

    c. _____

    d. _____

    e. _____

17. The flow path of air through the storage unit when heat is being stored is_____the air flow when heating from storage.

18. Why is air leakage more of a problem in all-air solar heating systems than in conventional forced air heating systems?

    a. _____

    b. _____

    c. _____

    d. _____

19. To achieve quiet operation, all blowers should be _____driven.

20. Dampers on all air systems be fitted with _____ _____ seals for positive shut-off and smooth operation.

T F 21. Solar domestic hot water heating is presently more economical than whole house space heating.

T F 22. The direct heating/thermosiphon system is well suited to northern climate.

T F 23. Direct water heating systems require drains to be installed in the collector loop to prevent freeze damage.

T F 24. Indirect solar water heating collector systems have been developed to overcome the freezing problems of direct heating systems.

T F 25. Indirect water heating systems can use either air or liquid (hydronic) collectors.

T F 26. Double wall heat exchangers are generally required in liquid solar water heating systems.

27. The simplest form of the solar domestic water heating system is the
    a. indirect heating/thermosiphon
    b. direct heating/thermosiphon
    c. direct heating/pump circulating
    d. indirect heating/pump circulating

28. In a direct heating/thermosiphon system the water storage tank must be
    a. located 1 to 2 feet above the collector
    b. located 1 to 2 feet below the collector
    c. made of fiberglass
    d. larger than in any of the other systems

29. Excessive hot water is prevented from entering the domesting hot water service line by installing a
    a. check valve
    b. P/T valve
    c. an automatic drain valve
    d. thermostatically controlled mixing valve

30. To prevent excessive build-up of hot water or steam in the storage tank a
    a. check valve is installed
    b. P/T valve is installed
    c. an automatic drain valve is installed
    d. thermostatically controlled mixing valve is installed

31. Among the major advantage(s) of using air rather than water as a transfer medium are/is:
    a. freedom from freezing and boiling
    b. no risk losing expensive fluid in collector loop
    c. no risk of damaging leaks
    d. all of the above

32. The major disadvantage(s) of using air rather than water as a transfer medium is/are:
    a. larger collector required
    b. larger piping required to connect components
    c. more energy required to circulate air
    d. all of the above

33. Describe two disadvantages of direct heating/thermosiphon solar domestic water heating systems.

    a. _____

    b. _____

34. A _____ valve is installed in the collect loop of a solar domestic water heating system to release excessive pressure and allow any steam which may be created to escape.

35. Label each of the lettered components of the direct heating/pump circulating system shown at the right.

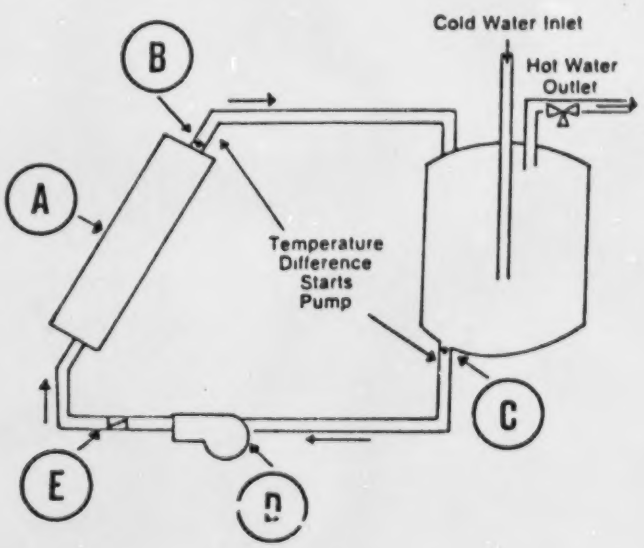
    a. _____

    b. _____

    c. _____

    d. _____

    e. _____



36. Using Table 8-1, calculate the daily BTU requirement for a family of four living in a three bedroom home which is supplied with service water at a temperature of 45°F. Assume that the desired temperature of the heated water is 155°F._____

Unit 5 - Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The shortage of fossil fuels is one reason why consumers are likely to purchase solar heating systems.

T F 2. When determining the size of solar heating system component, the heat storage unit is sized first and all other components are sized in relation to it.

T F 3. For heating only, the optimum angle of a solar collector with respect to the horizon is local latitude plus 15°F.

T F 4. Counterflow design of heat exchangers decreases heat transfer.

T F 5. The higher the approach temperature of the heat exchanger, the higher the efficiency.

T F 6. An air cushion tank provides the normal expansion of the liquid in a liquid solar heating system.

T F 7. The diaphragm in an air cushion tank prevents the air in the tank from mixing with the water.

T F 8. As the costs of natural gas, fuel oil and other forms of fossil fuel energy increase, it becomes less economical to install a solar heating system.

T F 9. The additional investment in solar heating equipment will increase the value of a home and is likely to increase the annual tax and insurance bills.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

10. Which of the following are considered when life-cycle-costing is applied to the design of a solar heating system?
    a. initial cost of the system
    b. expected life of the system
    c. cost of auxilliary energy
    d. all of the above are considered in life-cycle-costing

11. A collector which is oriented 30° west of south will operate at an efficiency of _____
    a. 0.93
    b. 0.98
    c. 0.90
    d. 0.97

12. An air solar system with 400 square feet of collector will require a storage unit containing _____cubic feet of pebbles.
    a. 200-400
    b. 150-300
    c. 250-600
    d. 450

13. A heat exchanger is installed in a liquid solar heating system to:
    a. increase the efficiency of the system
    b. prevent the collector fluid from boiling
    c. separate collector loop fluid from the storage loop fluid
    d. heat domestic hot water

14. A clearinghouse to obtain complete, up-to-date information about solar systems is:
    a. HUD
    b. National Solar Heating and Cooling Information Center
    c. ERDA
    d. none of the above

15. The FCHART collector sizing technique is
    a. very simple to use
    b. a very detailed sizing procedure
    c. available to customer through some collector manufacturers
    d. both B and C are correct

16. A procedure developed at Colorado State University for sizing collectors is based upon
    a. the FCHART system
    b. rules-of-thumb
    c. heat exchanger size
    d. economic analysis

17. Presently, for most locations the most economically solar heating installation will replace _____ percent of the fossil fuel energy requirement.
    a. 50-70
    b. 40-80
    c. 60-90
    d. 50-55

18. The ERDA computer program which contractors can use to determine optimum collector size and obtain heat loss calculation is known as
    a. FCHART
    b. Relative Areas Analysis
    c. Solocost
    d. Life-cycle-costing

In the following completion questions, place the correct number, word, or phrase in the blank(s) provided with each question.

19. A home located in Seattle, Washington has a heat loss of 60,000 Btuh for 20°F average outside and 70°F average inside temperature. What size collector will be required if 50% of the energy requirement is to be replaced by solar energy using a liquid system and collector tilt of 53°? Use Table 2-10 in SMACNA Standards.

    _____sq ft.

20. One of the simplified procedures outlined in this lesson provided a separate divisor for air and liquid systems. Also, two choices of collector tile and three choices of percent of solar contribution are given. What is the title of the document where these data can be found?

    _____

21. Simplified solar collector sizing procedures do not all produce the same results. Why is this so?_____ _____

    What must the designer/technician know when applying any of these techniques?_____

22. List ten factors which affect the life-cycle-cost of a solar heating system.

    _____ _____

    _____ _____

    _____ _____

    _____ _____

    _____ _____

23. Referring to the sample Solocost analysis, Figure 6-8, identify the values for the following input parameters:

    a. Collector tilt_____degrees

    b. solar system fixed initial cost $_____

    c. property tax rate_____ .

24. Referring to the output of the sample Solocost analysis, Figure 6-8, identify the following:

a. initial solar investment $_____

b. collector size _____square feet

c. annual proportion of load provided by solar_____%

d. rate of return on net cash flow_____%

Unit 4 and 5 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Solar heating equipment manufacturers may use their own sizing procedures.

T F 2. There is only one accurate way to determine the collector size for either the air or liquid system.

T F 3. A fixed collector array will satisfy the same percentage of the heat demand consistantly in all buildings in a given location.

T F 4. Doubling the size of the collector means doubling the heat output.

T F 5. Counterflow between hot and cold fluids improves heat transfer.

T F 6. Modern expansion tanks may be open to the atmosphere.

T F 7. Typically there are three blowers in an air system.

T F 8. Minimizing blower horsepower and air leaks are important considerations in an air system.

T F 9. Properly designed, the auxilliary system operates more hours per day than the collector loop.

T F 10. List duct coil BTU ratings may be reduced by non-uniform air velocity over coil.

T F 11. Sensors are placed at the inlet and outlet of the collectors for system operating purposes.

T F 12. In a closed loop hydronic system, more than one pump may operate at a given time.

T F 13. A heat pump can provide both heating in winter and cooling in summer.

T F 14. Because of excessive cost, DHW systems should not be installed alone.

T F 15. The thermosiphon system requires a low speed circulating pump.

T F 16. The thermosiphon system would be simple to operate in Florida.

T F 17. Safety valves are required for thermosiphon DHW systems.

T F 18. When heating DHW, the auxiliary system should be used only when solar insulation is insufficient.

T F 19. A relief valve to relieve pressure must be plumbed to an open drain.

T F 20. Air system collectors are larger than liquid system collectors when used for DHW of similar capacity.

T F 21. Almost any type of heat exchanger meets the code for DHW systems.

T F 22. By designing a 60% January hot water demand system, it would accommodate almost 100% of the June demand.

T F 23. There are numerous styles of heat exchangers.

Fill in the blanks with the word (or words) which most accurately completes the thought.

24. As a rule of thumb, the collector area required for space heating is equal to _____ the floor space being heated.

25. The FCHART is a table to determine _____ _____

26. To accommodate the expansion of water in a closed loop system, _____ _____ _____ tank is installed.

27. PSIG means _____ _____ _____ _____ _____

28. When heating from storage, the auxiliary system operates only during _____ stage demand of thermostat.

29. Collector efficiency at times of both high and low insolation may be increased by _____ _____ pumps.

30. A reasonable rate of consumption for DHW is _____ gallons per person per day.

31. List the four essential solar system operating modes.

a. _____

b. _____

c. _____

d. _____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

32. Typical collector efficiency for DHW is probably
a. 10% c. 70%
b. 40% d. 100%

33. When justifying solar installation for economic purposes, the expense most applicable is the:
    a. cost of equipment
    b. cost of labor
    c. tax break
    d. life-cycle cost

34. Optimum tilt angle for solar heating is latitude plus_____degrees.
    a. 0
    b. 5
    c. 15
    d. 30

35. Optimum tilt angle for DHW is latitude plus_____degrees.
    a. 0
    b. 5
    c. 15
    d. 30

36. The desired heat exchange approach temperature is:
    a. 0
    b. 10
    c. 20
    d. 30

37. Air cushion tanks can be located a few feet
    a. above the collector
    b. below the collectors
    c. above the storage unit
    d. below the storage unit

38. To prevent water from flashing to steam at the top of a collector, the
    a. static pressure is increased
    b. static pressure is decreased
    c. air vent is closed
    d. balance valves are adjusted

39. A diaphragm style air cushion tank allows for using_____cushion tanks.
    a. larger
    b. smaller

40. When ethylene glycol is used at a 50% concentration, expansion tanks must be_____in size.
    a. increased
    b. reduced

41. In the summer, when there is no immediate heat demand for DHW, the air system collector loop:
    a. continues to circulate hot air
    b. continues to heat the water
    c. exhausts to the atmosphere
    d. overheats the collector

42. The component that prevents scalding DHW water temperatures is:
    a. a heat controller
    b. a mixing valve
    c. an air vent
    d. the dual thermostat

43. Total pressure loss in an air system may be as high as _____inch of water.
    a. 0.3
    b. 0.6
    c. 0.9
    d. 1.0

44. A common air velocity inducts would be_____feet per minute.
    a. 200
    b. 400
    c. 800
    d. 1200

45. The least effective low temperature liquid space heat system with solar assistance is the:
    a. liquid to air unit
    b. hydronic baseboard unit
    c. heat exchanger unit
    d. low pressure storage unit

46. When the collector loop cannot supply enough heat directly the
    a. house gets cold
    b. storage unit heat is used
    c. auxilliary heat is used
    d. circulating pumps operate in reverse

47. A disadvantage of a heat pump as auxiliary heat may be:
    a. ineffective movement of the liquid
    b. use of unstable liquids
    c. large space that the pump occupies
    d. cost of electricity required to operate them

48. Differential thermostats are typically set to start when the temperature difference between collector and storage is about_____
    a. $3^{o}F$
    b. $6^{o}F$
    c. $10^{o}F$
    d. $20^{o}F$

49. The simplest DHW system to operate is the _____system.
    a. thermosiphon
    b. liquid circulating
    c. air circulating
    d. combination of B and C

50. The most difficult DHW system to integrate into the structure is the _____system.
    a. thermosiphon
    b. liquid circulating
    c. air circulating
    d. combination of B and C

51. Check valves prevent:
    a. overheating the collector
    b. short cycling
    c. reverse circulatin
    d. system drain-down

52. In the direct heating/pump circulating DHW system, _____prevents freezing.
    a. antifreeze
    b. reverse circulation
    c. high speed pump action
    d. a drain-down valve

53. The first concern in sizing is:
    a. heat storage unit
    b. air handler
    c. collector
    d. heat exchanger

54. In the indirect heating/pump circulation DHW system,_____prevents freezing.
    a. antifreeze or special fluid
    b. reverse circulation
    c. high speed pump action
    d. a drain-down valve

Unit 6 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Concentrating collectors "funnel" the heat to the absorber.

T F 2. Concentrating collectors pivot during the day.

T F 3. Flat plate collectors can be placed on any side of the roof.

T F 4. Diffuse radiation is unimportant to solar heating.

T F 5. Flat plate collectors are more popular than concentrating collectors.

T F 6. Flat plate collectors are most efficient at noon.

T F 7. Heat energy is the result of solar insolation.

T F 8. Most radiation that strikes the cover is absorbed by the glass.

T F 9. "Long wave conversion" reduces reradiation losses through glass covers.

T F 10. Plastic is a better material than glass for cover plates.

T F 11. The average annual outdoor temperature may determine the number of cover plates needed on a collector.

T F 12. Any kind of glass is as good as another for cover plates.

T F 13. Most efficient collectors have a vacuum between plates.

T F 14. Black paint is not applied to aluminum absorber surfaces.

T F 15. Absorber plates have absorptivities of 60% or less.

T F 16. Liquid collectors are larger than air collectors because of the space needed for piping.

T F 17. Fluid travels upward in all types of liquid collectors.

T F 18. A 30 psi system is classified as a low pressure system.

T F 19. Fluid tubes are always attached to the top surface of the absorber plate.

T F 20. Antifreeze can be used in liquid solar collectors as in automobile radiators to avoid freeze up.

T F 21. Electrolysis is more apt to occur in an air system.

T F 22. Polyurethane foam is the only insulating material for collectors.

T F 23. Since wood rots, collector frames should be made only of metal.

T F 24. Air through a collector array travels from the top of the roof toward the eave.

T F 25. Collectors do not need to be attached flat against the roof.

T F 26. Outdoor temperature can affect collector efficiency.

T F 27. A high temperature at the collector inlet will reduce collector efficiency.

T F 28. Data for collector efficiency are collected at or near noon.

Fill in the blanks with the word (or words) which most accurately completes the thought.

29. Two basic types of collectors are _____ and _____

30. The two transfer systems contain _____ and _____

31. The parts of a solar collector are:

1. _____

2. _____

3. _____

4. _____

5. _____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

32. Liquid flow rates through collectors are established near which number of gallons per minute?
a. .01 gpm/sq ft
b. .02 gpm/sq ft
c. .003 gpm/sq ft
d. .004 gpm/sq ft

33. Flow rates through air collectors are established near which number of cubic feet per minute?
a. 12 cfm/sq ft
b. 9 cfm/sq ft
c. 6 cfm/sq ft
d. 3 cfm/sq ft

34. The average absorber plate temperature is typically:
    a. 100°F.
    b. 150°F.
    c. 200°F.
    d. 250°F.

35. Heat energy that is visible is above
    a. 200°F.
    b. 500°F.
    c. 800°F.
    d. 1000°F.

36. The "blackbody" refers to the:
    a. collector frame
    b. absorber plate
    c. insulation
    d. none of the above

37. The main disadvantage of plastic covers is poor:
    a. heat transmission
    b. sheet stability
    c. sealing qualities
    d. light transmission

38. Various manufacturers of air system collectors use_____to increase conductivity.
    a. insulation
    b. slow speed blowers
    c. polished duct work
    d. fins

39. Sketch the tube patterns in the rectangle representing three collector designs.

Serpentine	Grid, direct	Grid, reverse

Unit 7 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. All substances can absorb or give off heat.

T F 2. There is approximately six hours difference between typical winter and summer solar exposure.

T F 3. Rock requires less storage space because it is harder.

T F 4. Water and air are the only substances used for heat storage.

T F 5. To retain a comparable amount of heat energy, wax requires a larger heat storage tank than water.

T F 6. Phase change storage systems are not presently used as much as sensible heat storage systems.

T F 7. The best place to locate a heat storage unit is outside the building because it would not take up living space.

T F 8. An attic is an ideal location for a heat storage unit.

T F 9. The only problem with placing a storage unit above ground and outside is its poor appearance.

T F 10. A storage unit can be "too large" for a given system.

T F 11. To warm a space evenly requires a heat storage unit.

T F 12. A reasonable capacity for a liquid storage tank is up to two gallons of water per square foot of collector surface.

T F 13. Heat storage system sizes are calculated according to the coldest possible temperature in a given locality.

T F 14. One way to account for heat from internal sources when calculating daily heat demand is to lower the estimated inside temperature 5°F.

T F 15. A heat storage unit should be adequate for an overnight supply of energy.

T F 16. A heat storage/collector system cannot be economically sized to supply a 100% annual heat load.

T F 17. The liquid storage tank must be heavily insulated.

T F 18. Watertight connections are easy to make for concrete tanks.

T F 19. Almost any fiberglass tank will be satisfactory to store heated water.

T F 20. Several small tanks may be as practical as one large tank for liquid storage.

T F 21. A storage unit that provides 50% of the heat demand is about the maximum size that can be built economically.

Fill in the blanks with the word (or words) which most accurately completes the thought.

22. An alternative to sensible heat storage is a _____ _____ _____

23. Changing one pound of ice to steam requires _____BTUs.

24. Attic heat storage could be used for a _____ _____system when heating _____ _____ _____

25. Sensible heat storage systems usually use _____or _____as the storage material.

26. The size of the storage unit depends on the size of the _____ and the _____

27. It is inadvisable to use an aluminum collector without protection because of corrosion from _____

28. The liquid storage unit that is the most expensive to install would probably be made of _____

29. Pebbles for an air system storage unit are about _____ in diameter.

30. Two types of pebble beds are _____and_____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

31. The specific heat of water is:
    a. one degree
    b. one BTU
    c. one BTU per pound
    d. one BTU per pound per degree F rise

32. Phase change refers to:
    a. BTUs of insolation
    b. heat of fusion
    c. loss of BTUs
    d. weather changes

33. An advantage of phase change materials is that they:
    a. absorb more heat than water
    b. rarely need to be replaced
    c. are inexpensive
    d. insulate easily

34. A "too small" storage unit
    a. increases collector efficiency
    b. reduces collector efficiency
    c. saves money in construction
    d. wastes little or no heat

35. A reasonable capacity for an air system storage unit is up to_____ cubic feet of rock per square foot of collector surface.
    a. one
    b. two
    c. five
    d. ten

36. Thermal stratification in a pebble bed means that:
    a. the temperature of the bed is constant
    b. there are layers of varying temperature
    c. hot air is heavy
    d. dirt prevents heat absorbing

37. Three advantages of storing liquids are that:

    a._____

    b._____

    c._____

38. Five disadvantages of storing liquids are that:

    a._____

    b._____

    c._____

    d._____

    e._____

39. Some advantages of the hot air storage system are that:

    a._____ c._____

    b._____ d. _____

40. Disadvantages of air storage units are that:

a._____

b._____

c._____

41. Three materials commonly used to construct liquid storage units are:

a._____

b._____

c._____

(Refer to SMACNA Standards for questions 42-44).

42. The lowest likely temperature for 99% of the total winter hours in Fargo, North Dakota is_____

43. Cleveland, Ohio is likely to have a minimum temperature of _____ during 97½% of the winter hours.

44. The average winter temperature in Wilmington, North Carolina is _____

Unit 8 - Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The word fluid as used in these lessons refers to both liquid and air.

T F 2. Pump sizing is not very critical to the solar heating system.

T F 3. Piping creates little or no resistance to liquid flow.

T F 4. Pump capacity decreases as head pressure increases.

T F 5. Pump specifications cannot be established until flow resistance is calculated.

T F 6. Larger pumps are required in the drain-down system as compared to a closed loop system of camparable size.

T F 7. Pumps rated at 150 psi are recommended for collector loops.

T F 8. One-speed pumps are as effective as two-speed pumps.

T F 9. Conventional furnace blowers may be installed in solar collector systems using air as the fluid.

T F 10. Static pressure is the type of air pressure measured in automobile tires.

T F 11. In low pressure systems, velocity pressure is most often used as a design standard for moving air.

T F 12. A system's performance cannot be predicted before it becomes operational.

T F 13. A thermostat is an actuator,

T F 14. A solenoid valve is an actuator.

T F 15. An outdoor thermostat is never used in conjunction with the collector (fan) circulation system.

T F 16. A differential thermostat measures temperature in more than one place at the same time.

T F 17. Some thermostats operate because of the difference in expansion of two metals.

T F 18. A bellows/diaphragm sensor must be open to the air to allow liquids to expand.

T F 19. A thermistor functions because of an internal change in electrical resistance.

T F 20. Corrosion will not effect the sensitivity of a thermistor.

T F 21. Thermistors are manufactured in various mountings.

T F 22. A transformer may be designed to either step-up or step-down voltage.

T F 23. Collector loops must be filled manually.

Fill in the blanks with the word (or words) which most accurately completes the thought.

24. The primary circuit connects the _____ to the _____

25. Pump capacity is given in _____ per _____

26. To prevent freeze-ups, liquid collector loops are protected by _____ or _____ _____ _____

27. The most common heat exchanger used between collector and storage is called the _____ and _____

28. Three types of pressures that apply to air movement are _____, _____ and _____

29. An air system should operate at a point where the _____ and _____ curves intersect.

30. The two elements of a control system are the _____ and the _____

31. The first stage of a two-stage thermostat calls for heat from the _____ or _____

32. The second stage of a two-stage thermostat calls for heat from the _____ _____ _____

33. The grease-like material to keep thermistors from losing sensitivity is called a _____ _____ _____

34. Thermistors contain a _____ _____ element.

35. Electrically powered valves are called _____ valves.

36. In an air system, an electrically powered _____ functions like the _____ in a liquid system.

37. A relay is a(n)_____switch.

38. The specialty item that keeps a closed liquid system operating between specific pressure limits is the_____ _____

39. Valves that adjust flow rates through the collector array are_____ valves.

40. To reduce corrosion among dissimilar metal piping and components, they are installed by using_____unions.

41. A manual fill system includes a:

A._____

B._____

C._____

42. The fan system curve, or balance point, can be changed by:

A._____

B._____

C._____

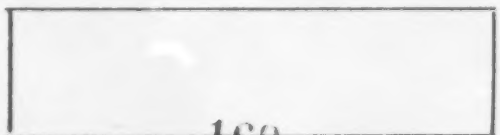
In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

43. Liquid moving pumps operate with a _____:
a. reciprocating action
b. syphoning action
c. pulsating action
d. centrifugal action

44. One psi of pressure is equal to:
a. 0.43 feet of water
b. 1.00 feet of water
c. 2.32 feet of water
d. 3.00 feet of water

45. The valve that allows fluid movement in only one direction is a:
a. check valve
b. pressure relief valve
c. balance valve
d. pressure reducing valve

46. Complete the drawing for a shell and tube heat exchanger.



Unit 7 and 8 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Although spelled differently, insulation and insolation have the same meaning.

T F 2. The lens of a concentrating collector must remain perpendicular to the rays of the sun.

T F 3. Flat plate collectors are equally efficient any time of the day.

T F 4. Operating temperatures are the same for all types of collectors.

T F 5. A serpentine piping design is used in concentrating collectors.

T F 6. Air spaces between cover plates are sealed from each other.

T F 7. About 95% of the heat that strikes an absorber plate passes into it.

T F 8. Fluid systems refer to either air or liquid being used to transfer heat.

T F 9. Any size blower could be used for the differently designed air collectors.

T F 10. Liquid transfer tubes may only be suspended above or below the absorber plate.

T F 11. "Drain-down" is an alternative to using antifreeze in collector loop.

T F 12. Aluminum is a good material for collector tubing because it can be shaped easily.

T F 13. Metal and fiberglass may be used for collector frames.

T F 14. The reason for needing a storage unit is that solar heat is variable and interruptable.

T F 15. The higher the specific heat of a substance the better it will perform to store heat energy.

T F 16. Water will hold about twice as much as heat as rock for the same volume.

T F 17. Phase change storage can be smaller than water storage for a given BTU capacity.

T F 18. Wax gives off heat when it cools and solidifies.

T F 19. Phase change materials will never be practical.

T F 20. A storage unit cannot be constructed that is considered "too" large.

T F 21. Collector efficiency will be reduced by a storage unit which is too small.

T F 22. A solar heating system must have a heat storage unit.

T F 23. When estimating maximum building heat loss, the average daily temperature is used.

T F 24. Rock will hold heat longer than water.

T F 25. Rocks in a storage unit must be washed periodically if not protected by filters.

T F 26. Standard fiberglass thanks have been proven very servicable even when liquid temperatures approach the boiling point.

T F 27. Glasslined tanks may be the fastest to deteriorate.

T F 28. The basement is the only place that pebble storage can be placed.

T F 29. Blowers are placed in the circuit to take air from storage and move it through the collector.

T F 30. Pressure drop means that fluid flow is being opposed by friction.

T F 31. A "drain down" circuit is always an open loop system.

T F 32. Inhibitors may be added to closed loop circuits.

T F 33. Antifreeze or other special fluid may be added to closed loop circuits.

T F 34. Air systems do not really need to be balanced.

T F 35. Thermistor operation is due to the change in resistance of a wire wound element.

T F 36. A thermistor needs to be mounted within about 10 feet of its controller.

T F 37. Thermistors are fairly standard in design but there are numerous mounting practices.

T F 38. The component in a liquid solar heating system that is furthest from the ground is a float-type air vent.

T F 39. Fill systems can be either manual or automatic.

Fill in the blank(s) with the word (or words) which most accurately completes the thought.

40. Two types of collectors are the _____ and _____

41. The alternatives to primer and black paint on an absorber plate are called _____ surfaces.

42. The most effective liquid collector is the _____ _____ _____

43. Two popular insulating materials for collector frames are _____ and _____ _____

44. Flow rates for an air system will be about _____ to _____ cfm per sq ft of collector.

45. Flow rates for a liquid system will be about _____ to _____ gpm per sq ft of collector.

46. Two ways to contain heat are with the _____ and _____ _____ storage systems.

47. Selecting a storage medium involves its _____ _____ _____ and _____ of the materials.

48. Two disadvantages of a liquid system caused by temperature change are _____ and _____ points.

49. To move fluids, _____ in a liquid system perform the same function as _____ in the air system.

50. To control fluids, _____ in the liquid system perform the same function as _____ in the air system.

51. Two important pressures in duct systems are _____ pressure and _____ pressure.

52. A control device to measure temperature in two locations is a _____ controller.

53. The first of a two stage thermostat calls for heat from the _____ or _____ and the second activates the _____ _____. _____

54. The three commonly used heat sensing devices are _____,
_____/_____and_____

55. To prevent overpressurizing in a liquid system a(n)_____
tank is installed.

56. The use of _____valves and_____makes
component replacement convenient.

In the following multiple choice questions, choose the phrase which most correctly completes the statement, and circle the corresponding letter in front of the phrase.

57. Transparent covering would be less useful if they could not:
a. respond to the heat demand of a building
b. be removed for cleaning
c. change temperature rapidly

58. The preferred cover plate materials is:
a. acrylic plastic
b. low iron glass
c. high silica glass
d. not listed above

59. Collectors installed in Minnesota and Louisiana would
a. be the same
b. differ in mounted height
c. have the same tilt angle
d. require more covers in Minnesota

60. A "blackbody" refers to the:
a. absorber plate
b. collector frame
c. black rubber cover gaskets
d. heat transfer system

61. Present day selected coatings are:
a. extremely durable
b. highly reliable
c. relatively inexpensive
d. about as efficient as paint

62. Fins are used in air collectors to:
a. increase heat transfer
b. lower internal temperature
c. restrict air flow
d. support the absorber plate

63. A collector rated at 60% efficient indicates the:
a. average daily heat transfer
b. differences between inlet and outlet temperature
c. heat transferred at noon for given inlet and ambient conditions
d. amount of sunlight that strikes the collector in a given time

64. The best estimates of maximum heat contribution that can be economically built into a solar system is:
    a. 40%
    b. 60%
    c. 80%
    d. 100%

65. It is reasonable to build storage units for_____of heat requirement.
    a. one days
    b. two days
    c. five days
    d. ten days
    e. overnight

66. Locations for storage units means using space that is:
    a. the least valuable
    b. closest to the collector
    c. in the center of the building
    d. outside the structure

67. Electrolysis in a liquid system:
    a. increases the efficiency of the collector
    b. inhibits chemical action
    c. reduced the size of the storage unit
    d. causes piping to corrode

68. Normally, rock beds _____feet deep will cause a minimum of air pressure drop.
    a. two
    b. four
    c. eight
    d. ten

69. Closed loop and open loop systems differ because of the
    a. damper and valve system
    b. heat exchanger
    c. heat transfer medium
    d. design of the storage unit

70. A thermal compound is needed with some thermistors to:
    a. adhere them to an absorber
    b. glue them in a well
    c. protect them from air or water
    d. reduce heat loss

71. An electrically controlled valve is a:
    a. solenoid valve
    b. relay
    c. thermostat
    d. check valve

72. An electromagnatic switch is commonly called a:
    a. solenoid
    b. transformer
    c. relay
    d. controller

73. Control devices are used for:
    a. ease of installing the solar heating system
    b. safe and automatic operation
    c. setting manual valves
    d. all of the above purposes

Unit 9 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Liquid heat storage units can be put in place any time during construction.

T F 2. The bottom of the storage tank should be on the floor for stability.

T F 3. Collectors must be joined to each other as tightly as possible.

T F 4. Some collectors should be covered after installation so they will not overheat internally before being placed in operation.

T F 5. The reverse return array assembly is the easiest to balance.

T F 6. Centrifugal pumps must have positive water pressure on the intake side.

T F 7. In an open loop system, the heat storage unit must contain antifreeze.

T F 8. The open loop system is frequently installed in locations where subfreezing temperatures are rare.

T F 9. In long pipe runs, expansion must be considered.

T F 10. Short lengths of rubber hose can perform the same function as dielectric unions.

T F 11. Rough-in electrical installation includes locating sensors and thermostats.

T F 12. Rock must be uniform in size for the pebble-bed storage unit.

T F 13. Sensors are installed in air system collectors after they are solidly mounted on the roof.

T F 14. Ducts for air system collector loops are installed in the same manner as conventional furnace ductwork.

T F 15. Ductwork may be insulated inside as well as outside.

T F 16. Ductwork to blower connections are made with flexible connectors.

T F 17. Air filters are more critical in the liquid collector circuit than the air system circuit.

T F 18. An electronic air cleaner should not be placed at the inlet to the auxiliary heat source because of high velocity air movement.

T F 19. The air handling module contains most of the electrical controls for its operation.

T F 20. Insulation for the outside surfaces of air system ductwork is added after leak testing is done.

T F 21. Humidifiers cannot be used with all air solar systems.

T F 22. Relief valves in DHW system are typically rated at 50 psi just as the collectors.

T F 23. The setting for the mixing valve for liquid DHW is 140°F.

T F 24. A collector could be mounted flat on a 4/12 pitch roof but maximum output would be reduced.

T F 25. Pebble-bed storage units can be placed outside the structure.

T F 26. Liquid storage tanks can never be placed outside the structure.

Fill in the blanks with the word (or words) which most accurately completes the thought.

27. The practice of installing a solar heating system in an existing structure is called _____

28. Footing for liquid heat storage tanks are engineered according to the weight of the _____ and _____

29. The preferred collector mounting practice is to mount it to a roof constructed at the proper _____ _____ _____

30. Space must be allowed at the top of collector array for the installation of the _____ _____

31. Piping made of _____ or _____ are used for liquid collector loops.

32. Expansion tanks are sized according to the _____ and the _____ _____ in the system.

33. Aluminum metal strips in a _____ erode away and reduce chemical attack in the rest of the liquid collector loop.

34. The basic steps involved in roofing a solar heated building are:

A. _____

B. _____

C. _____

35. Three possible liquid collectors to collector assembly procedures are:

A._____

B._____

C._____

36. Three possible liquid collector array circuits are:

A._____

B._____

C._____

37. An air handling system module may contain:

A._____

B._____

C._____

D._____

38. Materials to insulate a solar heating system should have:

A._____

B._____

C._____

D._____

E._____

F._____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

39. Tank installation is done before the:
    a. basement floor is poured
    b. floor joists are placed
    c. subfloor is nailed down
    d. basement floor is installed

40. For drainage purposes a minimum pitch in piping is_____per 10 feet.
    a. ¼"
    b. ½"
    c. 1"
    d. 2"

41. An air handling module directs airflow for:
    a. space heating from the collector
    b. space heating from the storage unit
    c. space heating from the auxiliary heat unit
    d. all of the above

42. Four gallons of liquid per minute flowing through a ½" pipe at 422fps will have a pressure drop of_____psi/100 ft. (refer to textbook).
    a. 4.22
    b. 6.36
    c. 6.60
    d. 7.42

43. A 1" pipe at 5.57 fps with a pressure drop of 6.36 psi will flow at _____gpm.
    a. 4
    b. 8
    c. 15
    d. 25

Unit 11 Quiz

Please indicate whether the following statements are true or false by crawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Safe procedures are important in servicing a solar heating system.

T F 2. Collectors may reach temperatures well above the boiling point of water.

T F 3. A good designer will prescribe the precise location for every element of the system.

T F 4. Start-up begins after components are in place, leak tests are completed and electrical controls are installed.

T F 5. It is almost impossible to totally purge air from a liquid system at start-up.

T F 6. Capping drain valves after start-up will prevent accidental drain down.

T F 7. Controllers operate as a result of the electrical current flow through the sensors.

T F 8. The system installer should complete a checklist and give it to the customer.

T F 9. Instruments to balance a solar heating system must be calibrated regularly.

T F 10. Absorber panels are anodized and not subject to shipping or peeling.

T F 11. Duct leaks should be located before building is closed in.

T F 12. Sensors typically cannot be repaired in the field.

T F 13. Most electronic controls will have to be adjusted at the time of start-up.

T F 14. Some heat transfer fluids may deteriorate seals and gaskets.

T F 15. Manufacturers generally guarantee the efficiency of their solar equipment.

T F 16. Manufacturers are likely to guarantee solar heating systems if they manufacture all components and certify to the training of installers.

T F 17. Poor packaging and shipping practices are a major cause of system malfunction.

T F 18. There are more problems with low pressure systems than there are with high pressure systems.

Fill in the blanks with the word (or words) which most accurately completes the thought.

19. The two most prevalent servicing hazards are _____ and _____

20. Low voltage circuits of _____ volts is used for _____ _____ and _____

21. To insure that all air is removed from a liquid system at start-up the service man must _____ each day for several days of operation.

22. Equalizing the temperature at the top of a liquid collector array is done by an adjustment of a _____ at the top of the collector.

23. Sensor accuracy is affected by a _____ or lack of _____

24. Organized _____ _____ are essential to a systematic approach to balancing.

25. Clogged collector weep holes cause a _____ _____

26. Depositing a film on the inside of the collector from vaporizing materials is called _____

27. A limited warranty is free of defects in _____ and _____

28. Glycol in a collector loop should be about _____ % concentration.

29. Aluminum collectors will corrode rapidly unless a _____ is installed.

30. Fiberglass tanks must be rated for at least _____ ^{o}F.

31. Start-up involves:

A. _____

B. _____

C. _____

32. Periodic maintenance involves checking:

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

33. An air handler contains:

A. _____

B. _____

C. _____

D. _____

E. _____

34. If a motor fails to operate, the electronic control should be replaced only after completing four troubleshooting activities which are to:

A. _____

B. _____

C. _____

D. _____

35. The basic approach to troubleshooting is to:

A. _____

B. _____

C. _____

D. _____

36. Four main categories of system failure are:

A. _____

B. _____

C. _____

D. _____

37. The following list is typical of the tools needed to balance an air system.

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

38. "Out of adjustment" complaints result when the:
    a. heating capacity seems to be decreasing
    b. heating is uneven and drafty
    c. operating cost is increasing
    d. noise level is rising
    e. all of the above

39. Of the following, which does not affect the efficiency of a collector?
    a. condensation
    b. leakage
    c. dust
    d. cracked rubber mounts

40. The periodic maintenance of an air handler requires:
    a. damper adjustment
    b. testing concentration of antifreeze
    c. adjusting balance dampers
    d. lubrication

Unit 9, 10 and 11 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. It is not necessary to install a 100% auxiliary heat system.

T F 2. Retrofit is the practice of installing a solar heating system in an existing building.

T F 3. Heat storage units can be installed any place on a concrete slab basement floor.

T F 4. Glass lined steel tanks are virtually trouble-free.

T F 5. Since collectors are light weight, little truss and rafter reinforcement is needed.

T F 6. The fewer number of pipe fittings used, the lower the pressure drop.

T F 7. Roofing is applied after direct mounted collectors have been installed.

T F 8. Liquid collectors are usually placed with the outlet and inlet connectors at the top and bottom respectively.

T F 9. Collector panels must be thoroughly inspected before being hoisted into place.

T F 10. Expansion and contraction is not a problem of securely mounted collector panels.

T F 11. Solar systems may require larger expansion tanks than conventional water filled hydronic systems.

T F 12. If rubber hose is used in a liquid system it must withstand 150 psi.

T F 13. A getter column reduces corrosion.

T F 14. Sensors should be in place before rough-in electrical work is done.

T F 15. Leak testing a system is done before drywall is hung.

T F 16. Control panels can easily be located in cabinets or closets.

T F 17. Rough-in electrical work precedes weatherization.

T F 18. A pebble-bed does not require as much insulation as a liquid storage tank.

T F 19. When planning a collector array, it's good practice to leave room for adding more collectors in the future.

T F 20. Air filters are less important in an all-air solar system.

T F 21. Tight fitting dampers are crucial to the performance of all air systems.

T F 22. Wood frame construction cannot be used to erect a pebble-bed storage container.

T F 23. Standard sheet metal installation practices are not appropriate for solar duct work.

T F 24. Ducts may be insulated internally or externally.

T F 25. There is no danger of freeze up in an air collector solar domestic water heater.

T F 26. A closed loop DHW system may use 30 psi rated relief valve in collector loop.

T F 27. All DHW systems use 125 psi rated temperature/pressure relief valves.

T F 28. The area below a garage floor can be used for heat storage units.

T F 29. The more that fiberglass insulation is compressed, the more effective it becomes.

T F 30. Under certain conditions collectors can reach temperatures of 300°F.

T F 31. Some air remains in suspension in a liquid system and cannot be vented until the fluid is heated.

T F 32. The installer must design a different kind of sensor mount to be used in each specific location.

T F 33. Shorting out a sensor will simulate an extremely cold condition.

T F 3 . Disconnecting the collector sensor from the control simulates an extremely cold condition.

T F 35. Overloading is a common cause of failure in electrical equipment.

T F 36. Outgassing is the depositing of an oily or powdery film on a cover plate.

T F 37. A limited warranty means the product is free from defects in material and craftsmanship.

T F 38. Solar heating systems conform easily to the Home Owners Warranty plan available when a home is sold.

T F 39. All equipment should be labeled if it is hazardous.

T F 40. Plugged weep holes are a problem with ductwork.

T F 41. Solar heating systems are hazard-free.

T F 42. Very few communities have legislated special coding for solar heated building construction.

T F 43. Some states have passed "Right to Light" laws.

T F 44. Some standards have been developed for solar heating systems by the federal government.

T F 45. Building inspectors should be contacted before construction begins.

T F 46. Local jurisdictional problems may exist when solar systems construction contracts are negotiated.

T F 47. All money lending agencies consider solar heating systems to be an asset to the property.

T F 48. Collectors are considered high risk factors for comprehensive insurance.

T F 49. An installer should give all warranties and product information to the owner after the system is in operation.

Fill in the blanks with the word (or words) which most accurately completes the thought.

50. Footings must be sufficient to place liquid storage tanks_____ above the basement floor.

51. Rough-in electrical work includes running electrical service to the _____and wire to the_____

52. Rock storage units are generally constructed of_____, _____, or_____

53. Rough-in ductwork begins_____ _____ _____

54. Electrical service of_____V and_____V are required at the control panel but this is transformed to_____V for most control circuits.

55. Liquid DHW circuits are classified as_____loop or _____systems.

56. Minimum thickness of insulation for storage tanks should be_____ inches, and for pipes and ducts, it should be_____inches.

57. Start-up of a liquid system involves_____the system, testing_____and measuring_____

58. Anemometers, tachometers, and manometers would be needed to balance a (an)_____solar heating system.

59. A proportional control is needed for_____ _____ fans and pumps.

60. Right to light problems arise from interference from_____ and_____

61. Some examples of tax breaks as incentives to invest in solar heating are_____ _____and_____taxes.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

62. The roof pitch for direct mounted heating only collectors on building at 30^{o} latitude would be:
    a. 6/12 or $26\frac{1}{2}^{o}$
    b. 7/12 or 30^{o}
    c. 12/12 or 45^{o}
    d. 4/12 or $18\frac{1}{2}^{o}$

63. Collector sensors should be installed
    a. before inspection
    b. before hoisting the collector to the roof
    c. after hoisting the collector to the roof
    d. when installing electrical circuits

64. To drain properly, horizontal piping must have_____pitch for each 10 feet of run.
    a. ¼ inch
    b. ½ inch
    c. 1 inch
    d. 2 inches

65. Insulation requirements are engineered to:
    a. counteract heat loss
    b. fill the walls
    c. cover the foundation
    d. cover the ceiling joists

66. Much of the responsibility for equipment placement is delegated to the:
    a. architect
    b. designer
    c. installer
    d. owner

67. If a system is not performing properly major changes to the system should be made only after
    a. redesigning the system
    b. heat losses are reduced
    c. adding tubing to the collector
    d. using larger rocks in the pebble-bed

68. To insure air removal, at start-up of liquid system, the serviceman should:
    a. open all float vents
    b. loosen the collector connector
    c. check the system after a week's operation
    d. systematically open all bleeder valves

69. Sensors function because:
    a. water or air pass over them
    b. of the kind of controller used with them
    c. heat changes in their electrical resistance
    d. of reasons not listed

70. To balance an air solar heating system, servicepersons do not need to
    a. review the shop drawings
    b. obtain pump performance data
    c. adjust dampers
    d. have manufacturer's recommendations

71. The most difficult liquid storage tanks to seal are:
    a. concrete
    b. fiberglass
    c. glass-lined
    d. galvanized steel

72. Checking the getter column often involves
    a. adding lubricants
    b. changing aluminum strips
    c. cleaning the bowl
    d. adjusting the flow rate

73. A system may be out of adjustment if:
    a. its ability to heat is decreasing
    b. the heat is uneven
    c. operating costs rise
    d. all of the above occur

74. To keep from contaminating potable water, a solar system needs
    a. a pressure relief valve
    b. a back-flow check valve
    c. a balancing valve
    d. a shut-off valve